48 PAGES EVERY WEEK

No. 575, 20th JANUARY, 1973
EVERY MONDAY PRICE 10p

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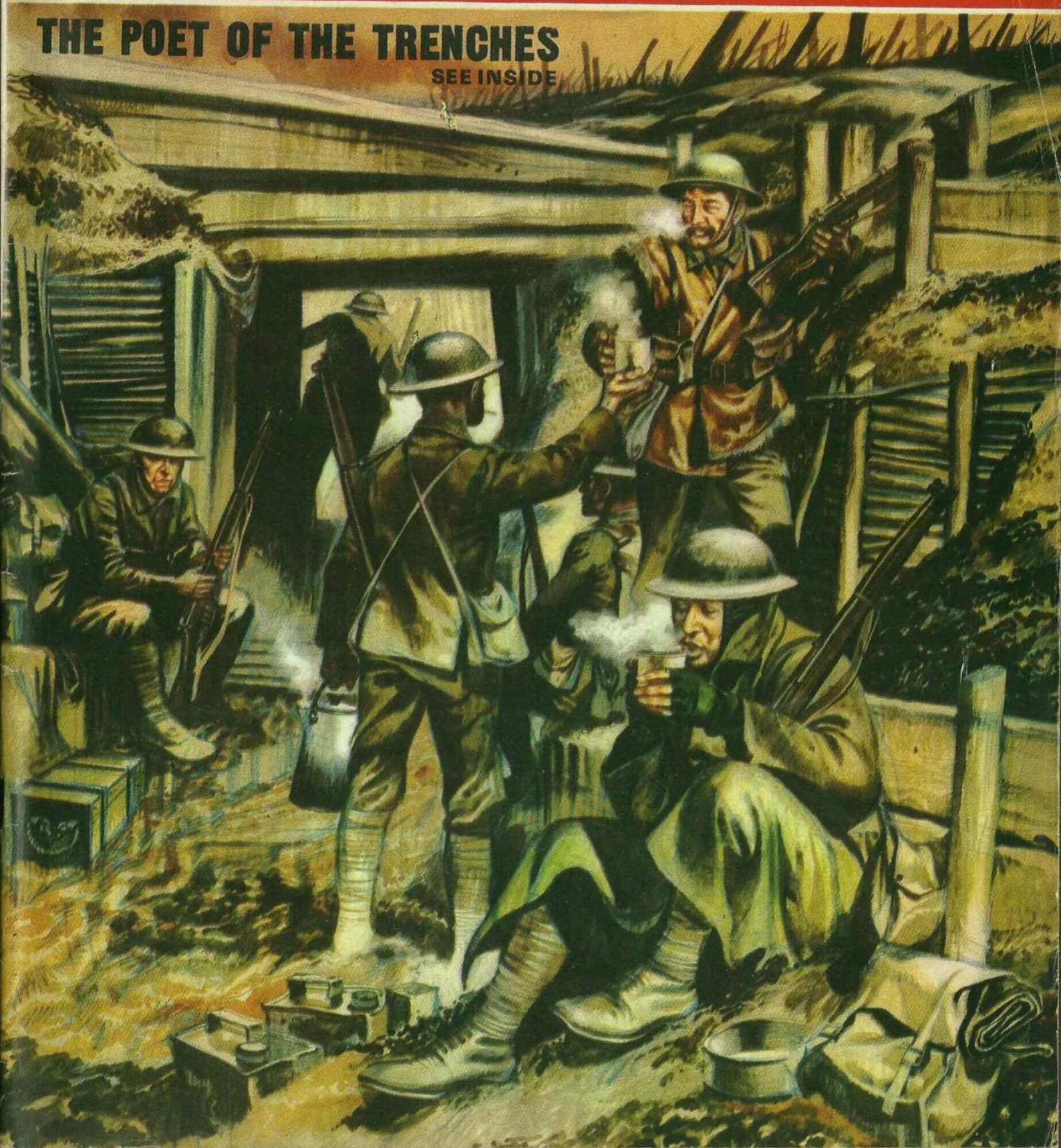
THE POET OF THE TRENCHES

SEE INSIDE



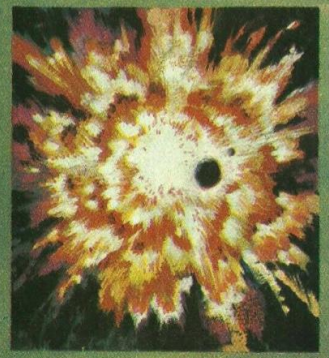
Modern Marvels

THE TIME TRAVELLERS

Einstein's amazing theory that we could travel through time, both to the past and to the future, sounds incredible. But it has been proved to be fact—and to the space travellers of tomorrow it may well be a frightening adventure

TIME-TRAVELLING is the simplest occupation in the world. You need no super-scientific devices to do it. Go outdoors on a clear night and look up at the sky. When you do so, you are travelling through time into the past.

You see the stars, not as they are now, but as they were many years ago. Many of them, in fact, are seen as they were long before Man appeared upon Earth. This is because light, which seems to fill the largest room instantly at the flick of a switch, has a speed limit. That limit is 186,000 miles per second, and nothing is known in the universe which moves faster. Earthly distances are so short that no time appears to elapse between the beginning and end of a light-ray's journey when both points are on the surface of this planet. But when we move out into the solar system, and beyond it to the stars, the speed limit becomes important.



If the sun vanished from the sky, even on the brightest of summer days, our eyes would not warn us of its disappearance until eight minutes afterwards, for this is the length of time light takes to travel the 93 million miles between Earth and Sun.

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Further out, across the incredible spaces separating our galaxy from the millions of others which make up the universe, light crawls to us from a time so remote that the surface of the earth may have altered many times during the trip. And for the same vast span of time, our own sun and planets have radiated light outward toward those distant worlds. If there are intelligent beings out there who can somehow build up a detailed picture from the light-rays reaching them from Earth, they could now be seeing a cloudy, jungle-covered globe where giant reptiles still rule.

Until quite recently, this sort of knowledge was of little interest to anyone other than astronomers and physicists, and possibly science-fiction readers. To the majority of people, it was a mysterious business, of no practical use, and all that it proved was that some scientists had vivid imaginations. The arrival of space flight has changed that situation. The huge Saturn rockets lumbering Moonwards from Cape Kennedy travel at only a tiny fraction of the speed of light, but they are merely the first step into space, the dugout canoe that will evolve into the ocean liner.

Man did not wait to conquer the earth, or even to explore it fully, before reaching out for the moon. And before his

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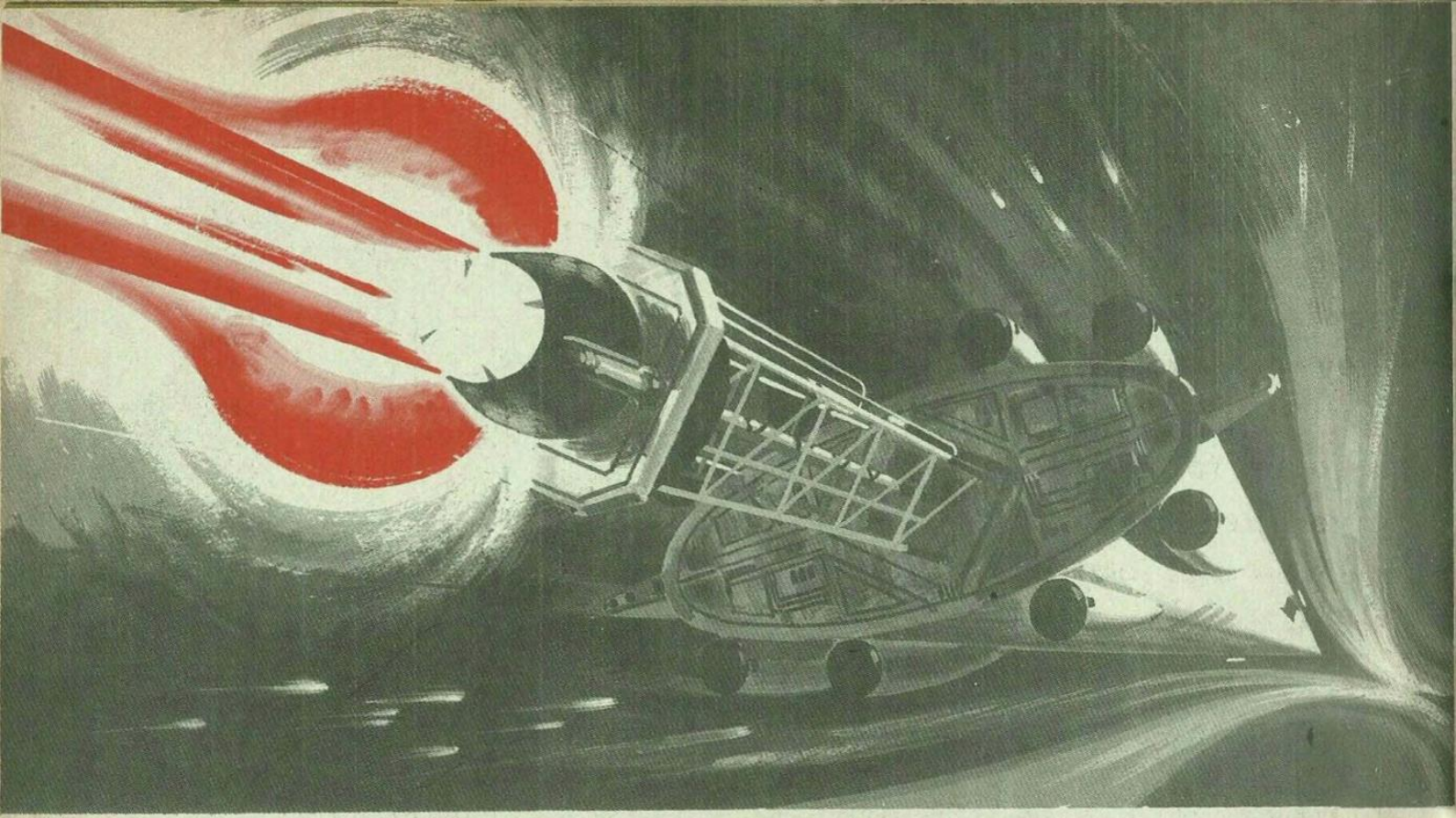
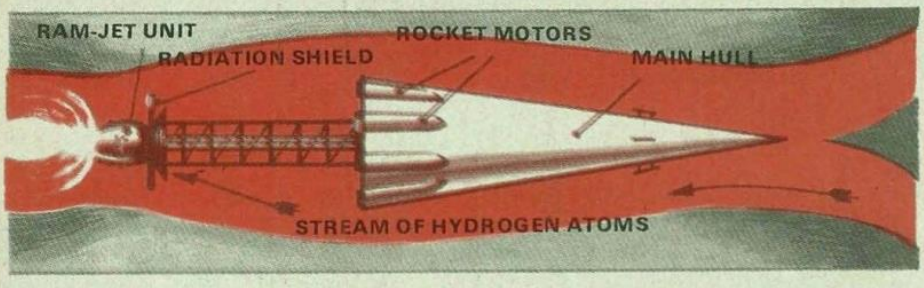
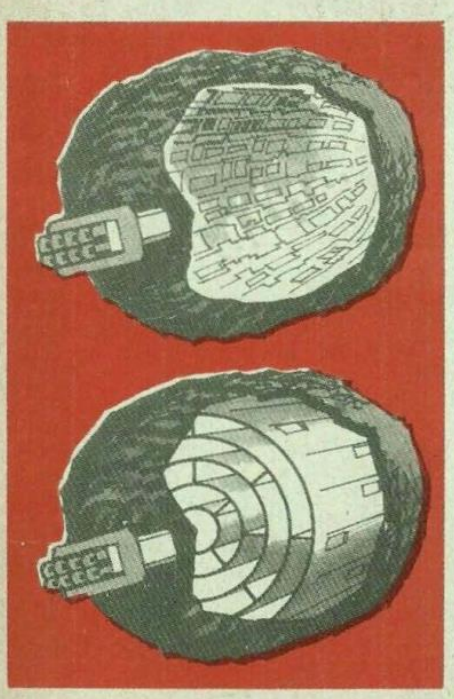
The " Noah's Ark " space ship in orbit round a possible destination planet with ports opening to despatch a space-shuttle type craft to explore and report.





An artist's impression of a " Ram Jet " ship, with the main propulsion in action (above). Left is a diagram of the ship. This craft would work by sucking in fuel as it moved forward and expelling it at the rear.

The possible layout for the interior of a "Noah's Ark" asteroid ship, with or without artificial gravity. It could contain a miniature landscape of fields and villages or concentric rings of decks.



spaceships have landed upon Pluto, he may well be aiming a craft at the stars. From this point onward, the ideas that once seemed no more than wild imaginings will be vitally important. For the first inter-stellar ship will fly on a voyage, not only into space, but also into time.

Many designs for an inter-stellar ship have been proposed. Among the more spectacular of these are the " Noah's Ark " and the ram-jet. Although they represent two very different answers to the problem of covering great distances in time and space, they have one thing in common. Neither can succeed unless some form of space-drive is developed which uses atomic energy. Chemical fuels have taken us to the moon, but they can never provide sufficient power to carry us to the stars. We may, indeed, have to wait for an atomic drive before men can travel to the outer planets of the solar system, over distances many thousands of times greater than that between Earth and Moon.

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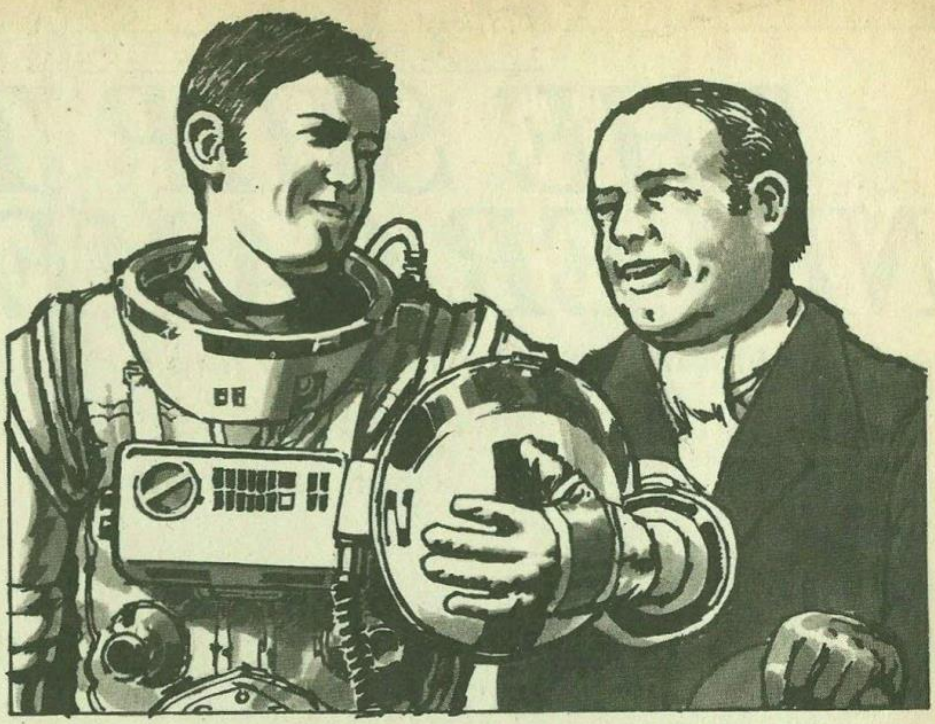
To grow crops and raise livestock on board ship is not so improbable as it may sound. Many farm animals are bred now in surroundings which are completely man-made, and crops such as wheat can be produced to suit a wide variety of soils and climates. Sealed off within its thick shell of rock and metal, the interior of the ark can maintain indefinitely whatever kind of " weather " the crew desire. Nothing will be wasted, for there will be no way to replace lost materials until another solar system is reached. All waste materials will be re-cycled and used again.

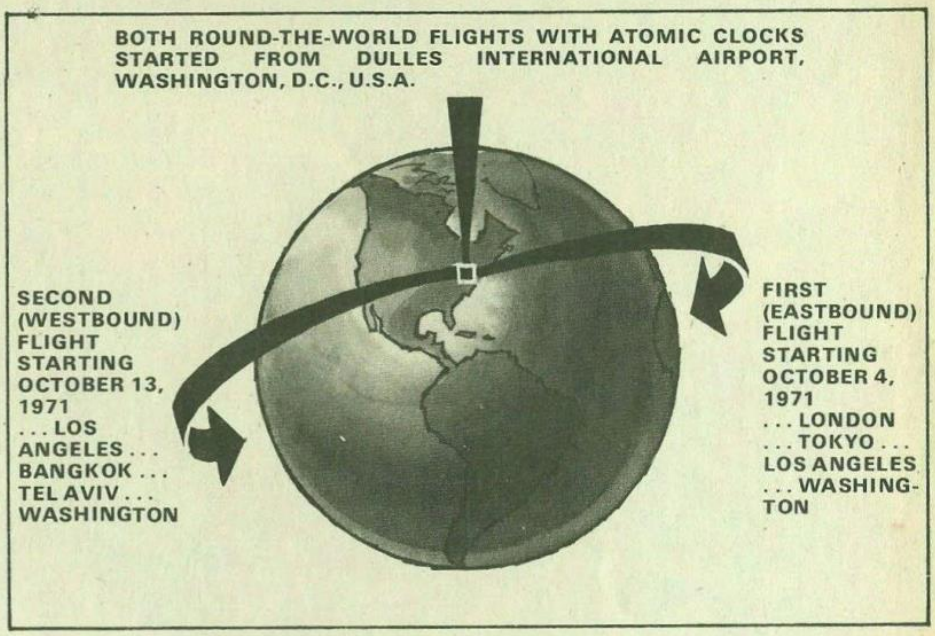
THE RAM-JET

The men and women who set out in such ships will be extraordinarily dedicated people. If the star at which they aim is a very distant one, only their great-great-great-grandchildren may live to celebrate the Ark's arrival at their destination. It is difficult to imagine that anyone would be willing to undertake such a journey.

Our time machine will be the first inter-stellar ship, and the space-time astronauts will always be strangers when they return to Earth from their long voyages, for they will have travelled out of the past and into the future



If a twenty-year-old astronaut went into space for a trip at the speed of light, he could return after two years to find that his twin brother was now middle-aged. Two years in space would be ten times less than the years that had passed on Earth.



These are the world-circling routes taken by four atomic clocks to prove the theory that time is lost when flying in an eastern direction and gained when flying in a western direction.

Because it offers the possibility of reaching speeds close to that of light, the alternative system — the ram-jet — may make it possible for men to reach the stars within their own lifetime. This craft works by sucking in fuel as it moves forward and expelling it at the rear, in the manner of a jet-plane. But the ram-jet's fuel is not the jet-plane's air and kerosene. Instead, it feeds upon the clouds of hydrogen which fill the spaces between the stars. Although these clouds are so thin that on Earth they would be regarded as an almost perfect vacuum, they will become denser as the speed of the ram-jet increases, just as air " piles up " before a speeding aircraft to form the well-known " sound barrier."

TIME TEST

When the atomic motors have set the ship in motion, a colossal scoop, powered by those same motors, will reach out ahead of it to gather in the hydrogen. This scoop is actually a magnetic field which seizes hydrogen atoms and rams them into the nuclear furnace which releases their tremendous energies. If you have watched iron filings arranging themselves into patterns under the invisible influence of a bar magnet, you will have seen a very small example of the forces involved. Moving through a universe filled with fuel, the ram-jet can burn it continuously, building up speed in a way denied to any ship which must carry its own supply.

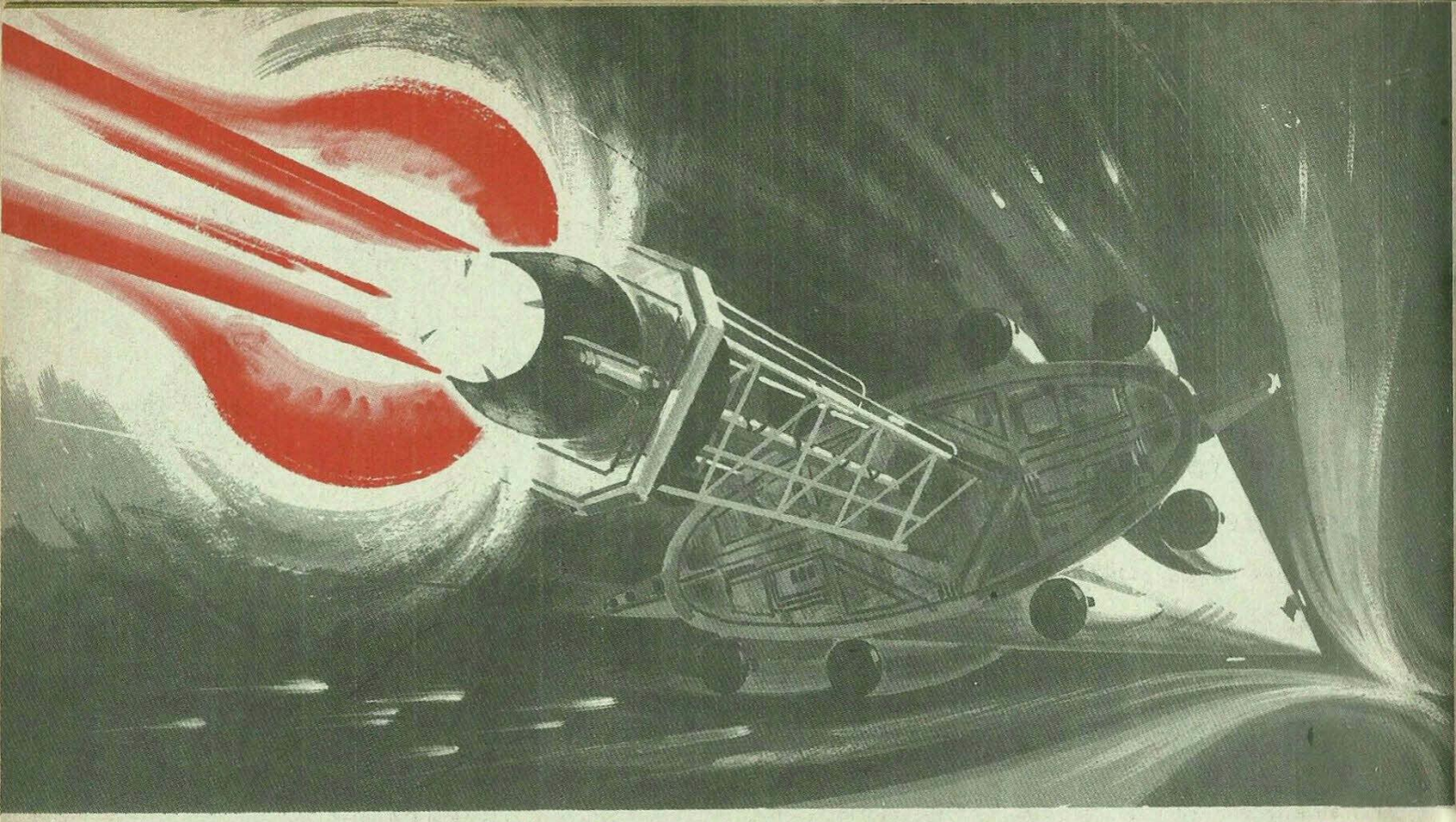
The real trouble for the inter-stellar astronauts will begin when they have learned how to travel almost as fast as light. For, according to the Theory of Relativity proposed by Dr. Albert Einstein, peculiar things begin to happen to time at this point. If, for example, a twenty-year-old astronaut went into space for a trip at light-speed, leaving his twin brother behind on Earth, he could return after two years to find that his brother was now middle-aged. The ship's clocks would have ticked away two years, and the crew would be exactly two years older, while ten times that number of years had passed on Earth.

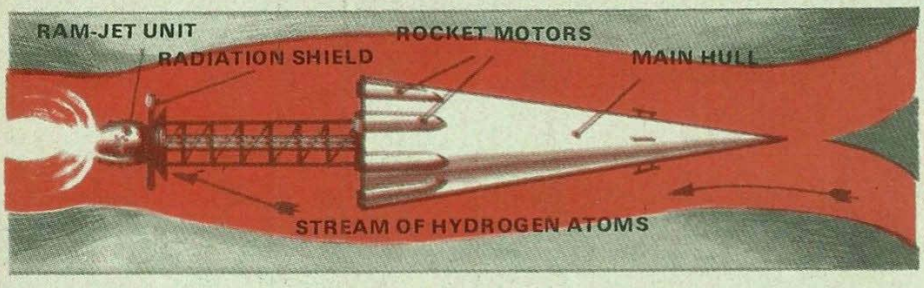
Einstein showed that a clock travelling in an eastwards direction would lose time when compared with a fixed clock on earth, and gain time when flying in a westwards direction.

This was proved when the Americans flew four, highly accurate atomic clocks around the world. They took the average of the time they showed and saw how this differed from the time showed by a clock that stayed on Earth.

There were variations, but these were so tiny that they were measured in tenths of a second. However, the experiment showed that Einstein was right. The clocks that flew in an easterly direction lost time, and those that made a westerly circuit gained time.

And so we can travel through time, both to the past and the future, although we have very little choice either way. We see only those portions of the past that are brought to us by the light of the stars. To see the future, we must move through space as well as time. Our time machine will be the first inter-stellar ship. The space-time astronauts will always be strangers when they return to Earth from their long voyages, for they will have travelled out of the past.





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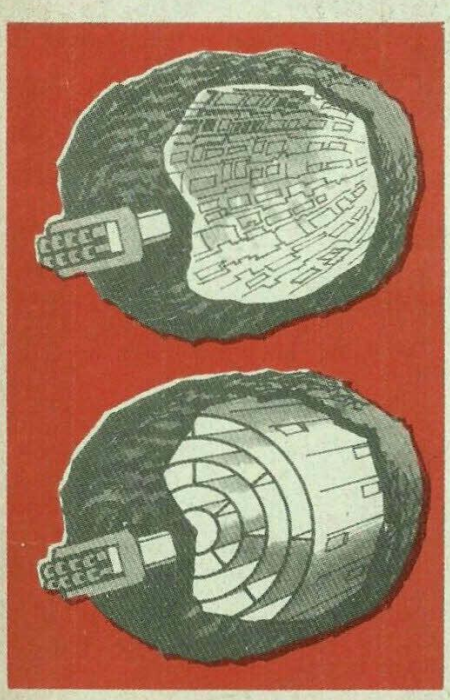

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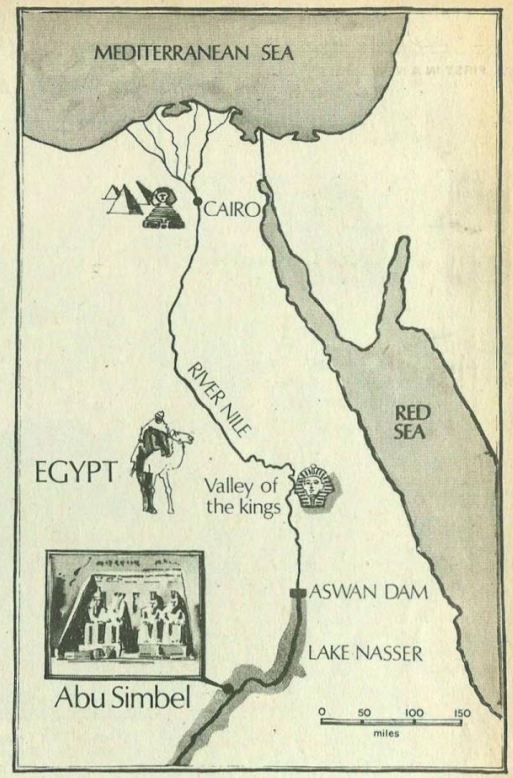
THE SPORT THAT'S ON THE UP AND UP

SEE INSIDE

THE MIRACLE THAT SAVED ABU SIMBEL

Threatened by the rising waters of the Nile, the mighty Temple of Rameses II at Abu Simbel was doomed to be lost for ever. It was a man-made miracle that saved it



At 210 feet above the water level, the colossi are re-assembled. Behind them, the giant dome which will support the blocks of mountain is being constructed over the re-erected temples.

TO save one of the greatest and most glorious monuments of the ancient world from destruction — that was the aim of the fifty-two nations which financed the gigantic operation of moving the mighty Temple of Abu Simbel and rebuilding it in a place safe from the Nile floods.

It has been called The Engineering Miracle of The Twentieth Century, and when one considers the sheer size of the monument, it is easy to see why the mammoth task of moving it is considered a miracle.

Hewn out of a cliff facing the River of Destiny, in about 1250 B.C., the great temple was built by Pharaoh Rameses II, the greatest builder of ancient Egypt. It is 108 feet high and 124 feet wide, and on the Temple's facade are enthroned four colossal figures of the Pharaoh, each 67 feet high. These massive statues have greeted the sunrise for 3,300 years and they reflect the majesty of ancient Egypt at the height of her power and glory.

When the seven classical wonders of the ancient world were named the Temples of Abu Simbel were sleeping undiscovered beneath a giant mass of sand in remote Nubia. There they remained concealed for over 2,000 years until 1812 when a Swiss traveller, exploring the Nile, discovered the temple of Rameses II's Queen, Nefertari. Four years later, an Italian explorer, Giovanni Belzoni, cut a narrow trench through the mountain of sand and arrived at the entrance of the Pharaoh's Temple. He squeezed into the Great Hall and there, lining the way towards the dark entrance of the Sanctuary cut 200 feet into the heart of the mountain, were eight huge statues of Rameses. Belzoni eventually reached the Sanctuary, but then decided to leave his wonderful discovery. Within months the desert sands had covered up all traces of the entrance to the Temple and Abu Simbel, once again, was left to sleep.

It was not until early in the twentieth century that the mountain of sand covering the temples was properly cleared and the majestic sight of Abu Simbel revealed itself to the astonished eyes of the world.

CONTINUED ON NEXT PAGE

The great statues of the Pharaoh can once more look down upon the River of Destiny as they have done for over 3,000 years-in safety and at peace

Then, having discovered this wonderful treasure from the long-distant past, the world soon stood in fear of losing it. Threatened by the rising waters of the Aswan High Dam, Abu Simbel, rightly acknowledged as the Eighth Wonder of The World, was doomed to be lost forever, and it would take a miracle of scientific engineering to save it.

Now, after years of careful preparation, and painstaking work, the mighty monument of the Pharaoh stands over 200 feet above the dangerous waters of the Nile, safe from destruction.

THE PLAN

Preparations to save Abu Simbel began in 1959 when the International Campaign for the Preservation of the Nubian monuments started to study the various ways by which the gigantic salvage operation could be accomplished. The Governments of the United Arab Republic and the Sudan called on UNESCO to launch a world-wide appeal for funds to save the treasures. Six hundred archaeological expeditions entered Nubia and just when the Nile waters had risen dangerously high at Abu Simbel, funds began to pour in from all over the world so that the salvage operation could at last begin.

By 1963 the method by which the Temples would be reconstructed was decided upon. They were to be cut up into 30 ton blocks and re-erected 210 feet above the original site.

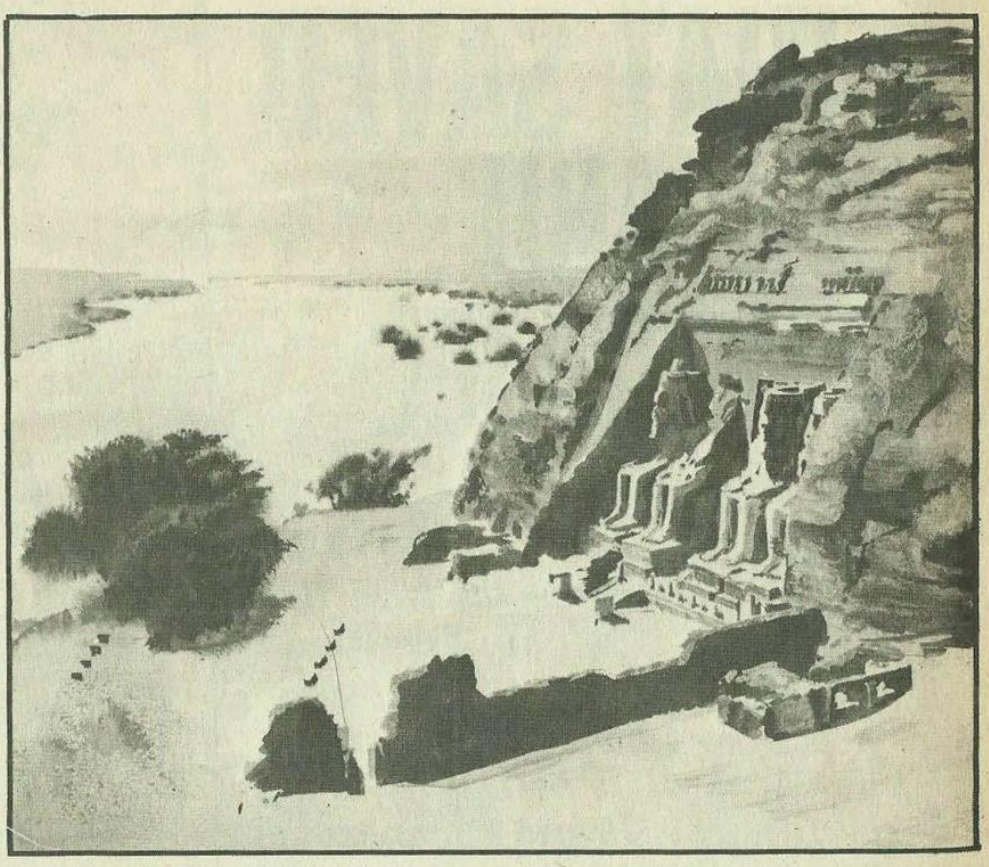
But first, a 1,100 foot long; 35 feet high coffer dam had to be quickly constructed to hold back the floods. By working day and night in temperatures rising above 30 degrees Centigrade, 360,000 tons of rock were moved for the construction of the dam so that it was finished by the end of 1964.

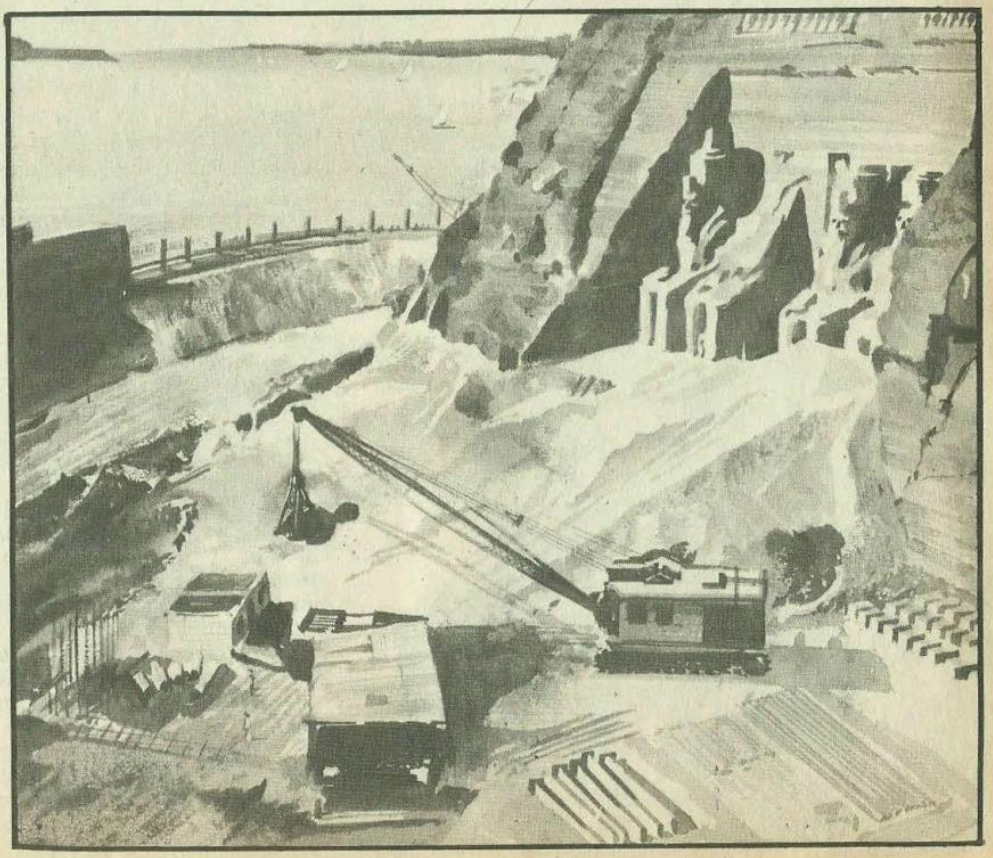
Whilst the dam was being built, the Great Temple and the four colossi, or figures, of Rameses II were buried in sand to protect them from falling rock. The top of the mountain was cut away from them so that the temples stood by themselves, no longer a part of the mountain.

DISASTER

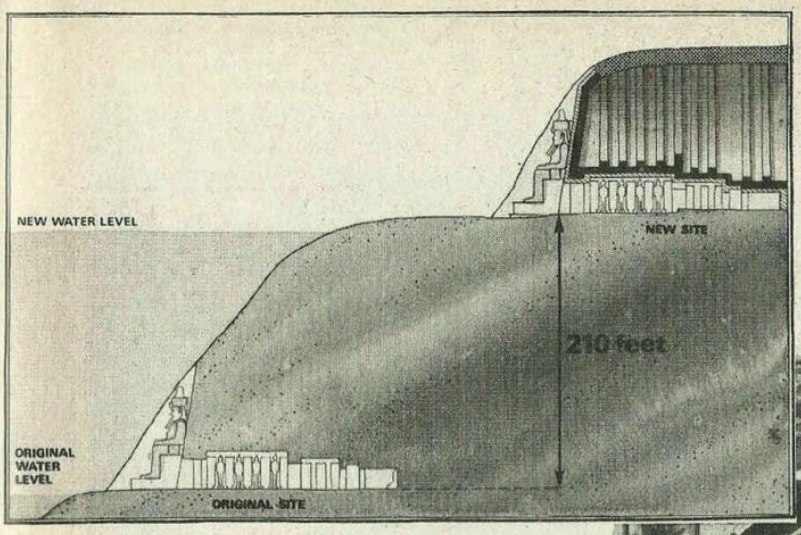
Then, disaster came. The whole fate of the operation hung precariously in the balance when monsoon rains in Ethiopia brought down torrential floods almost to the crest of the dam. For weeks, the saviours of Abu Simbel watched and waited in agonising suspense, hoping that the crisis would pass. Luckily, the flood *did* eventually pass and work continued.

The Great Temple was cut into 30,000 pieces weighing more than 11,000 tons and the Queen's Temple was then cut into 2,500 sections weighing more than 3,000 tons. Encased in rigid concrete "boxes" they were edged upwards a millimetre at a time and raised bodily on





Above: The Temple of Abu Simbel as it stood for over 3,000 years facing the River of Destiny. Below: The gigantic salvage operation in progress. While the coffer dam was being built the temple was buried in sand to protect it from falling rock.



Left: A diagram showing the original site of the temples, and the new site, 210 feet above the original water level.

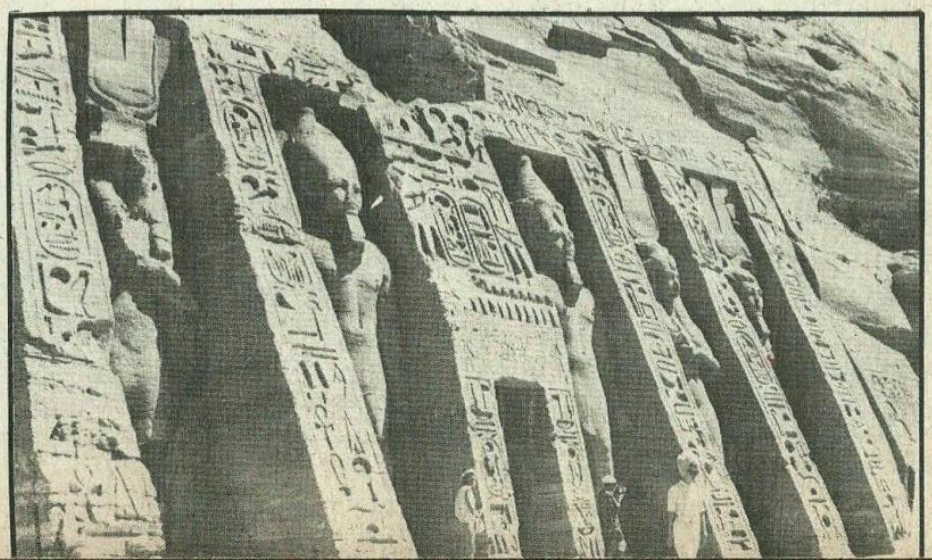
Right: Each of the huge statues of Rameses was first buried in sand up to the neck, and then cut into blocks so that they could be moved up to the top of the escarpment.

The Temple of Queen Nefertari on its original site. This, too, was saved from destruction.

250 hydraulic jacks each capable of lifting a thousand tons. Once the "boxes" reached the top of the escarpment, the temples were then rebuilt in exactly the same way as they were originally.

In their race against time and the menacing floods of the Nile, the salvage engineers and their machinery have succeeded in their magnificent task. For the first time in our history, a massive operation to save unique cultural treasures of our civilisation has been accomplished.

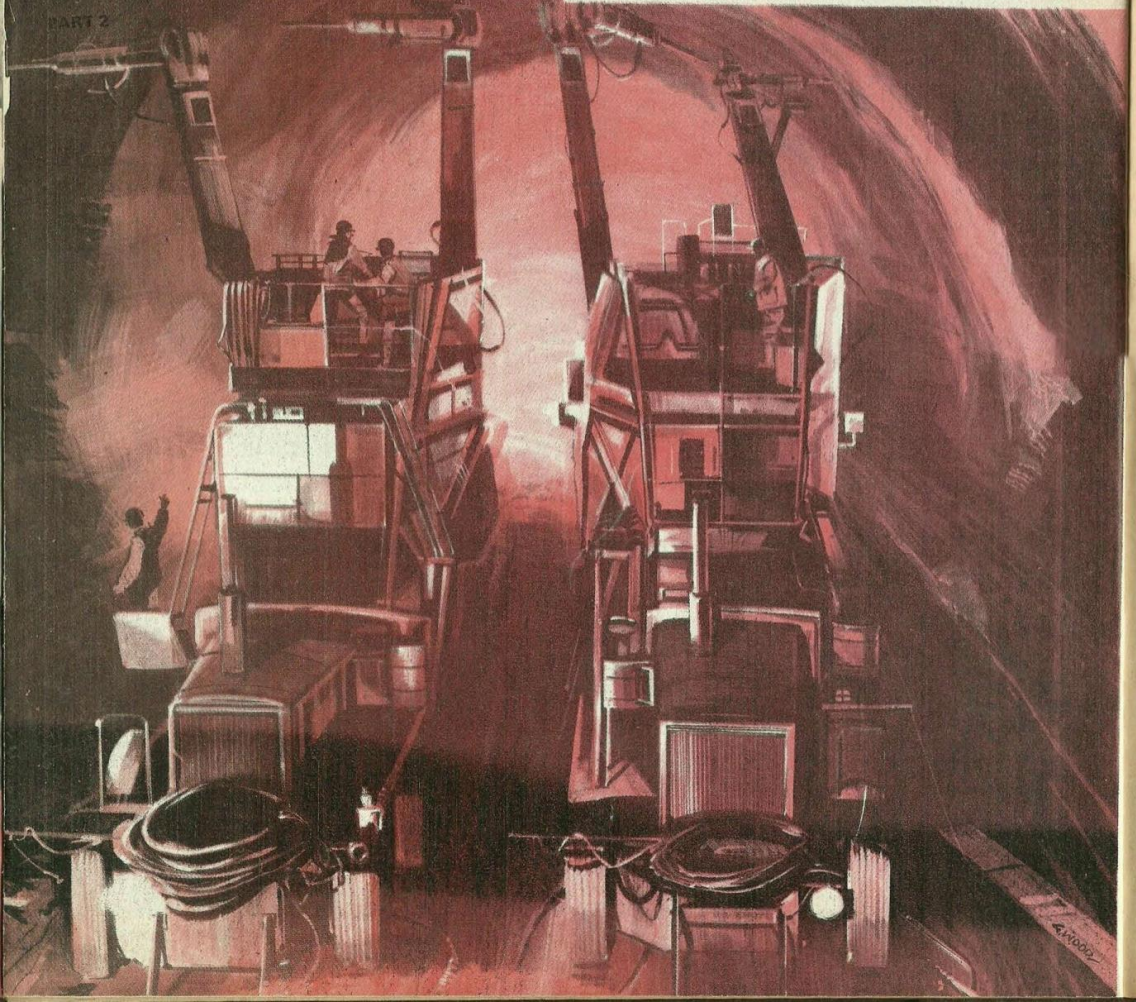
The great statues of the mighty Pharaoh can, once more, look down upon the River of Destiny as they have done for over 3,000 years, and greet many more dawns in safety and at peace.

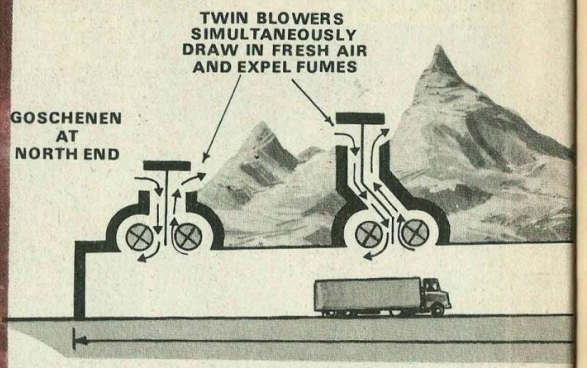


Modern Marvels

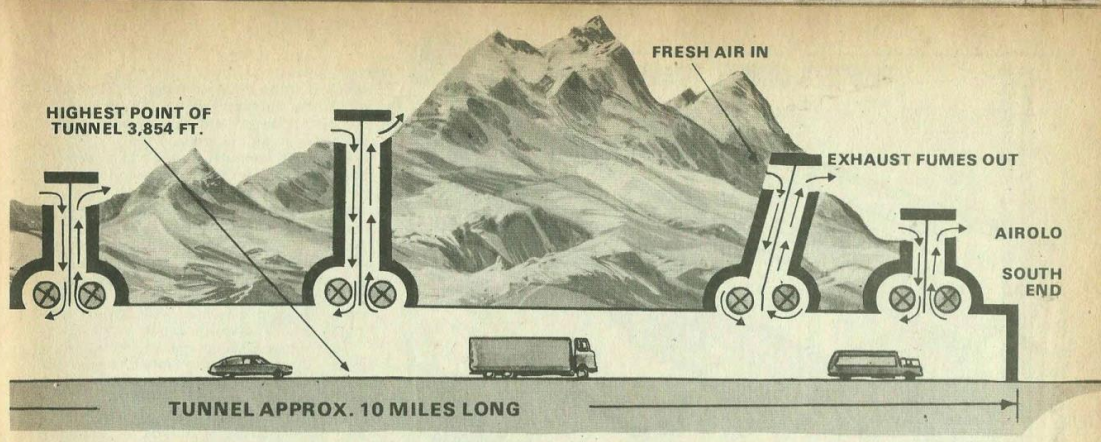
HIGHWAYS THROUGH THE EARTH

PART 2





A tunnel, once thought to be an enginee



ing impossibility, is being cut through ten miles of solid rock in the Swiss Alps. This, and the proposed English Channel Tunnel, will be two of the most remarkable feats in the history of tunnelling

A TUNNEL beneath the English Channel? Napoleon liked the idea. As Emperor of France, he had everything to gain and nothing to lose from a road link between his country and Britain.

But the British people did not share his enthusiasm for such a revolutionary project. For centuries, the people of Britain had felt secure behind the strip of water that separated their land from Europe. And Napoleon's ambitions towards greater and greater power were well known.

It would be easy for him to march his troops through the tunnel and add Britain to his list of conquests, they thought.

And so Napoleon's proposals, which he made to the British ambassador at the beginning of the 19th century, were turned down.

They were raised again in 1876, when Britain and France finally came to an agreement to link their two countries with a tunnel. They even went so far as to dig experimental tunnels for 2,000 yards on either side. But work was stopped in 1882, probably because of Britain's fears about the use an invader could make of the tunnel.

The idea came up again in 1914, but was stopped because the First World War broke out in that year.

Now it is being talked about once more, and the chances that it will at last be built are more rosy. No longer does Britain fear invasion from the continent, because modern warfare has produced more effective ways of subduing a country, principally by air attacks.

And the advocates of it are heartened by a geological survey which has shown that the project is technically possible. Most of the arguments now concentrate upon the most economical method to use.

The basic plan consists of two transport tunnels, each 24 ft. in diameter and spaced 74 ft. apart, driven through 33 miles of chalk beneath the sea bed.

Between them, and connected to them by passages, will be a smaller service tunnel, which could also act as an emergency escape route should part of the main tunnel become blocked.

Passenger and goods trains would use the main tunnels, through which would run special trains designed to carry cars and their occupants.

There is no doubt that this tunnel would be busy. The experts are even saying that there may be a need for a second tunnel before 1990.

How will these tunnels be built? One favoured idea is for a concrete tube laid in a trench dug in the bed of the Channel. Prefabricated, sealed tubes would be lowered into previously scooped out ditches from moving installation equipment. The sections would be joined up and the seals removed. Each section could measure over 300 ft. long.

The advantages of the Channel Tunnel are as apparent as those of another tunnel

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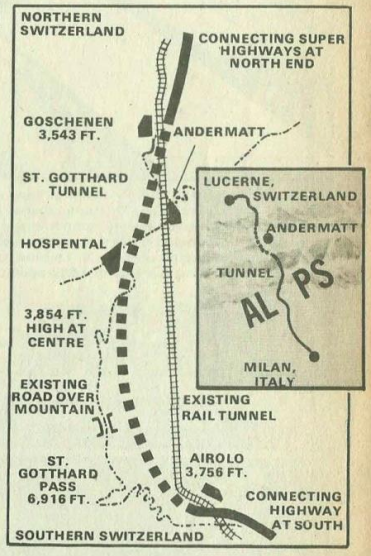
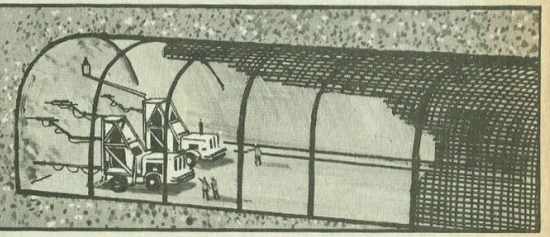
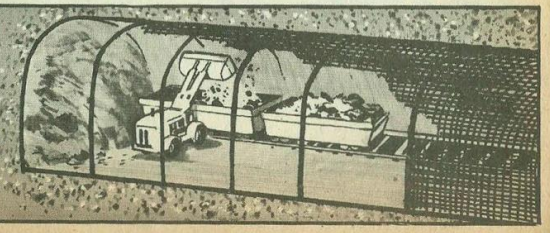
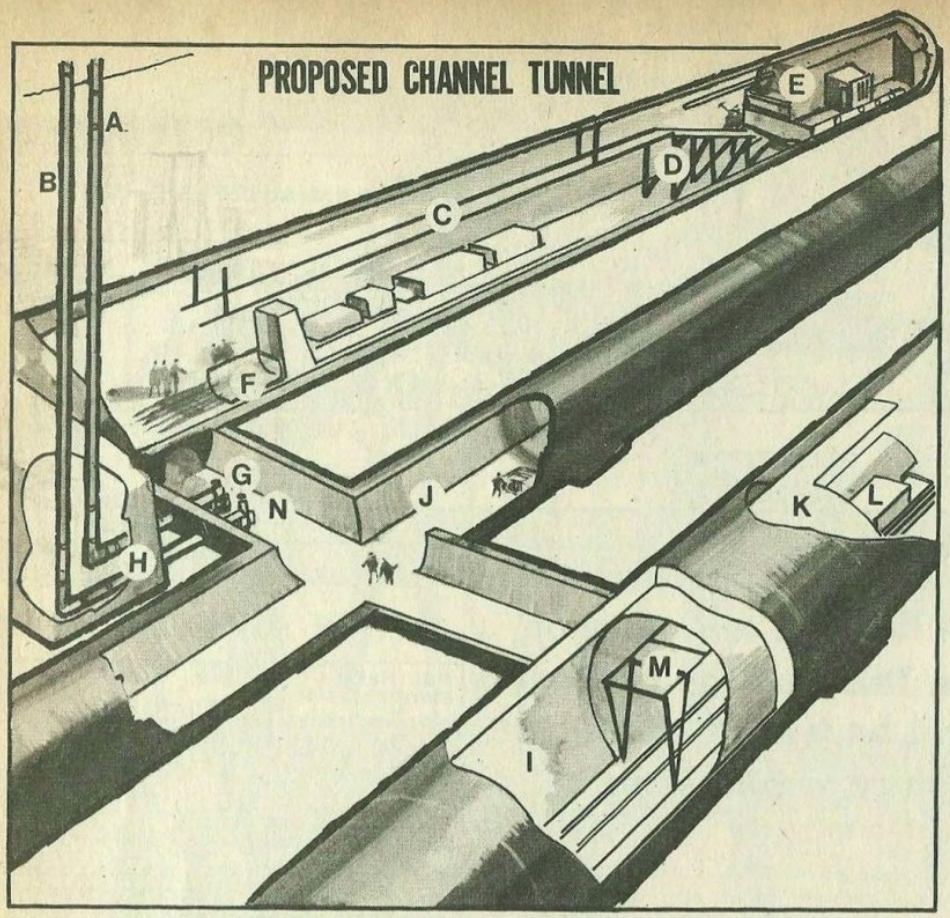




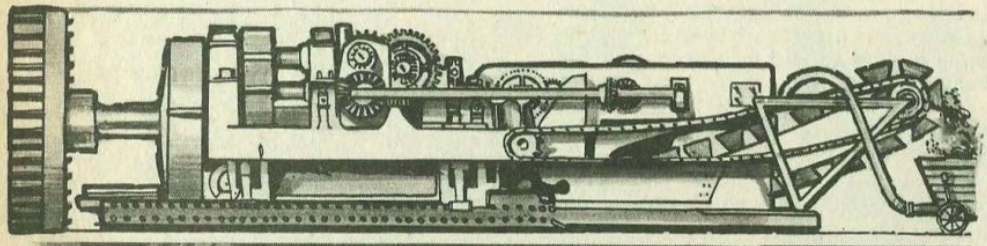
All around this page are pictures of one of the biggest projects ever undertaken — a ten mile tunnel through the Swiss Alps. On the right are the boom mounted drills.



After the holes are bored and the charges fired, the diesel-powered bucket graders (right) quickly fill the trucks with the rock. Once the train has pulled out, drilling is resumed.



A. Sea water inlet. B. Slurry disposal pipe. C. Telescopic conveyor belt. D. Steel rib carrier. E. Boring machine. F. Stone crusher and sea water mixer. G. Pumps to extract crushed rock and seawater. H. Pump house. I. Main tunnel. J. Service tunnel. K. Liquid concrete being pumped to seal against steel lining. L. Concrete mixer and pump. M. Portable trestle running on rails. N. Turbine to draw in seawater. Below is the Beaumont rotary clay-tunnelling machine of 1882 which bored a tunnel under the Channel.



The entrance to the Channel Tunnel, begun in 1880, is still in good condition and the workings are inspected regularly. But work on it was stopped in 1882.

which is to be driven through the Swiss Alps under the famous St. Gotthard Pass, one of the highest and most awesome of the peaks in this mountain range.

Extending ten miles through solid rock, this tunnel will run from Goschenen in the north to Airolo in the south.

It will be called the St. Gotthard Tunnel and, when it is finished sometime in 1978, it will be the world's longest vehicular tunnel.

Except for a rail link, the way through this part of the Alps at present is over a steep, twisting mountain road, which is impassable in the winter snows.

This tunnel will open the way to greater trade and travel between France, Belgium and other northern countries and Italy and the Mediterranean to the south.

While this tunnel is important, it is only one of a growing multitude of tunnel projects throughout the world. Among them are a tube train system in Budapest, an underwater car park in Geneva, a link between Spain and Africa under the Strait of Gibraltar and a tube train system for San Francisco.

The San Francisco system, which was recently completed, links San Francisco, which is bounded on three sides by water, with Oakland, on the American mainland.

For this project, the American engineers lowered 57 prefabricated sections of tunnel, made of tubular steel and reinforced concrete, into a trench, which had been dredged out of the floor of the bay. The tunnel sections, which were double-barrelled, were each 48 ft. wide by 24 ft. deep and about 330 ft. long. Divers were used to align the sections, which were welded together under the water.

When all the sections were complete, the water was pumped out and work on the interior began. Between the actual rail tunnels are two rectangular ducts which are used for ventilation and for carrying a service line.

Light-weight electric trains now speed through the twin tunnels at speeds of up to 80 m.p.h., once every 90 seconds at peak periods.

This tunnel, including the approaches on each side of the bay, is six miles long.

Britain has some ambitious tunnels, too. One of the most famous of these is the original Mersey tunnel, which was finished in 1934, after nine years of work.

Cars and lorries were able to drive through this tunnel for two and a quarter miles between Liverpool and Birkenhead, underneath the River Mersey.

But as more and more cars and lorries queued to go through it, the need for a second tunnel became obvious. This is the MT2, through which traffic is now flowing between Liverpool and Wallasey.

This tunnel has an inside diameter of 31 ft. 7 in., giving a roadway width of 24 ft. to take two traffic lanes, and it is exactly 7,360 ft. long from entrance to entrance.

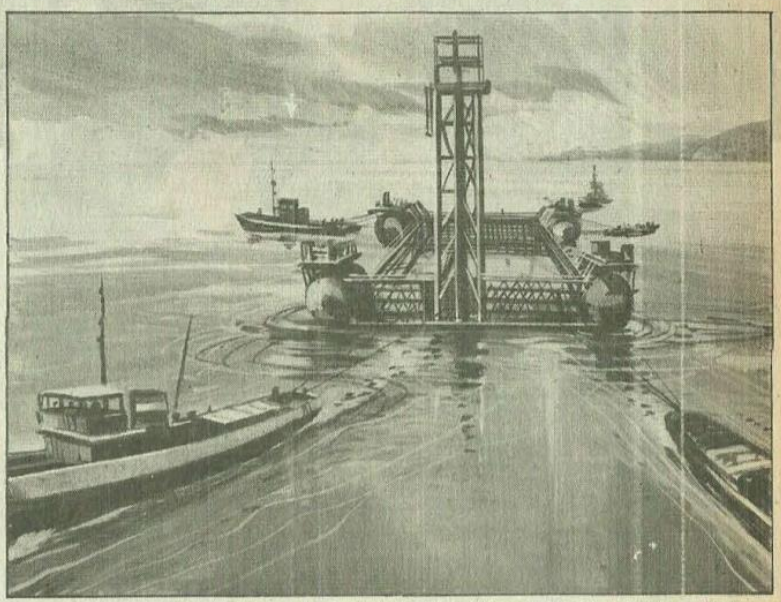
One of the marvels of this tunnel's construction was the use of a powerful boring machine called Big Mole. In twenty-seven months, this monster cut through 6,860 ft. of sandstone, 500 ft. of tunnel inwards from the Liverpool side having been dug by hand because it passed through clay.

Not only did Big Mole grind its way through solid rock as easily as a mole

burrows through earth, it also carried equipment behind it. This allowed a small gang of men to erect in position the big, curved concrete segments which formed the tunnel's lining.

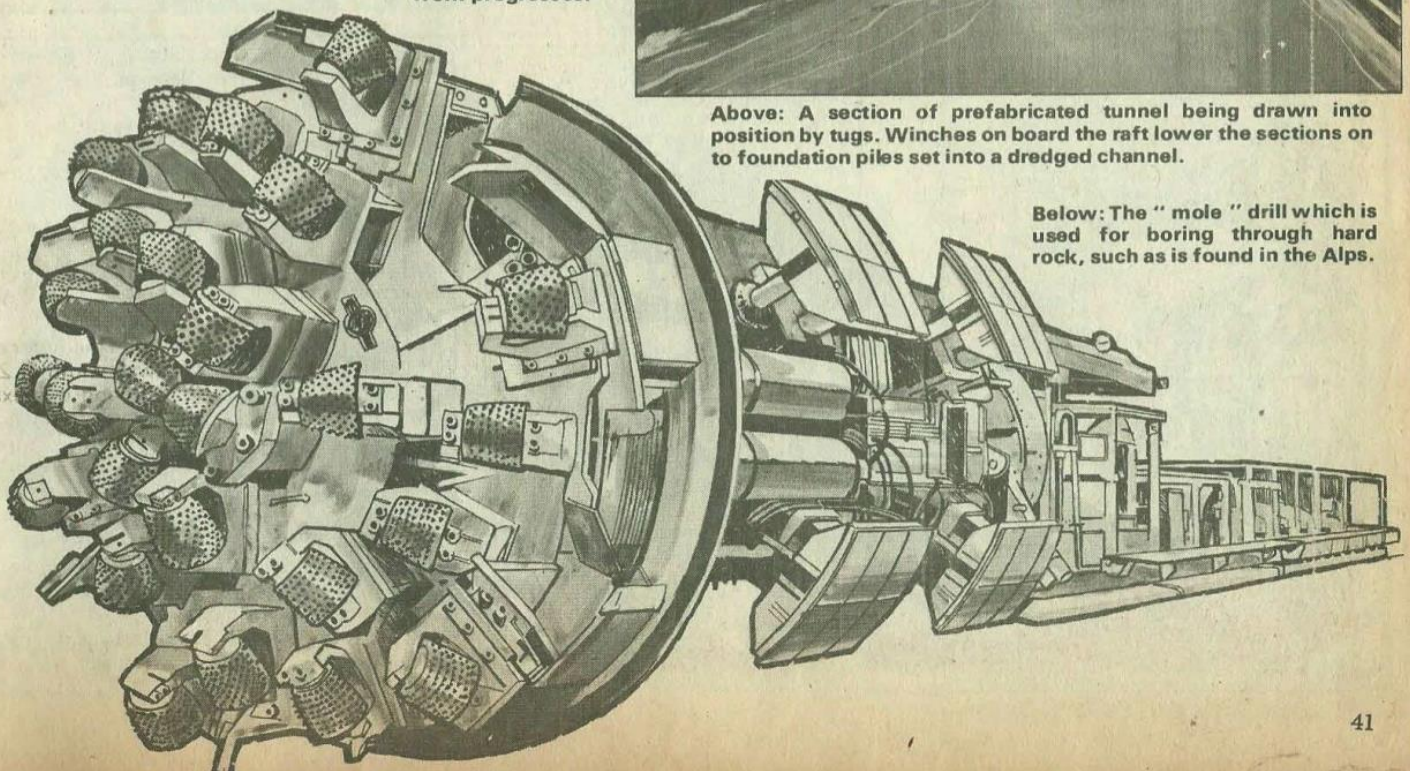
Thanks to Big Mole, the MT2 is an accomplished fact. But nobody really believes that anything will come of a fantastic plan to build a tunnel from the Antarctic to Australia, through which giant snowballs could be rolled to water the parched Australian deserts. But, think what a wonderful ski-run it would make.

Above: An impression of the rigs proposed for laying the English Channel Tunnel by the immersed tube method. The rigs, one for digging the shallow trench and one for laying the tube sections, have retractable legs. These enable them to move forward as work progresses.



Above: A section of prefabricated tunnel being drawn into position by tugs. Winches on board the raft lower the sections on to foundation piles set into a dredged channel.

Below: The " mole " drill which is used for boring through hard rock, such as is found in the Alps.



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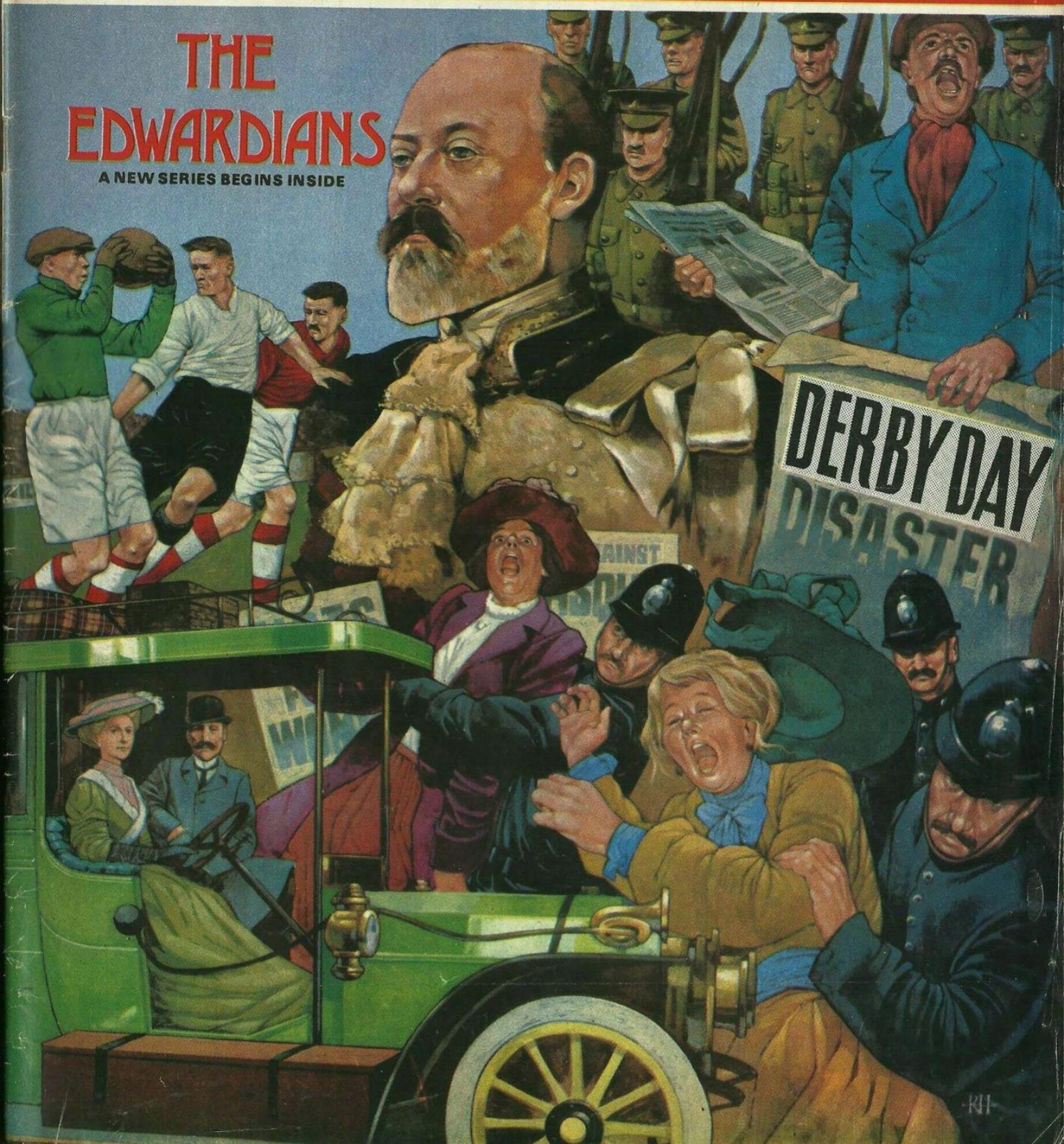

The X-24B Martin Marietta " lifting body " mounted on a pylon beneath the starboard wing of a Boeing B-52 " mother plane ". Inset: The X-24B has just been released at 45,000 feet and its rocket is being " lit-up " for a powered climb to 60,000 feet before " burn-out " and the glide back to the airfield.

Modern Marvels

THE WINGLESS WONDERS

Resembling super bath-tubs, wingless "lifting bodies" are paving the way for the day when space shuttle craft will be used again and again to carry men and materials into space and then return to Earth by gliding hundreds of miles through the atmosphere without engine power.

WITH the last Apollo mission to the Moon successfully completed, the United States has announced that its future space programme will be concerned with the development of a space shuttle craft. In the past, rockets and modules sent up into space and to the Moon have been " non-returnable," going into orbit round the Earth or falling back into the atmosphere to be burnt up. This has involved a tremendous amount of waste. The idea of the space shuttle is to make possible craft that can be launched time and time again by rocket and can then return to Earth by gliding on a long trajectory through the Earth's atmosphere to land at any airport.

To this end the United States has been experimenting for some years with " lifting bodies ", compromise air/space craft that will be equally suited to space

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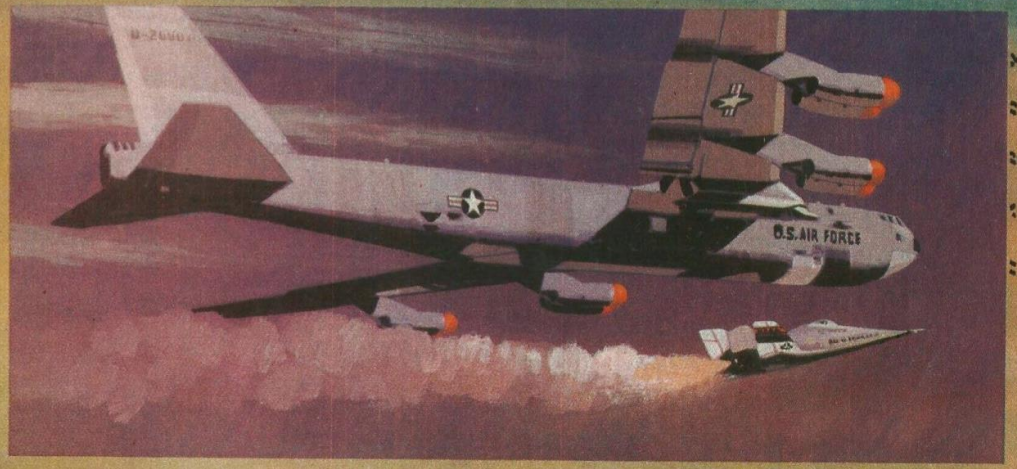
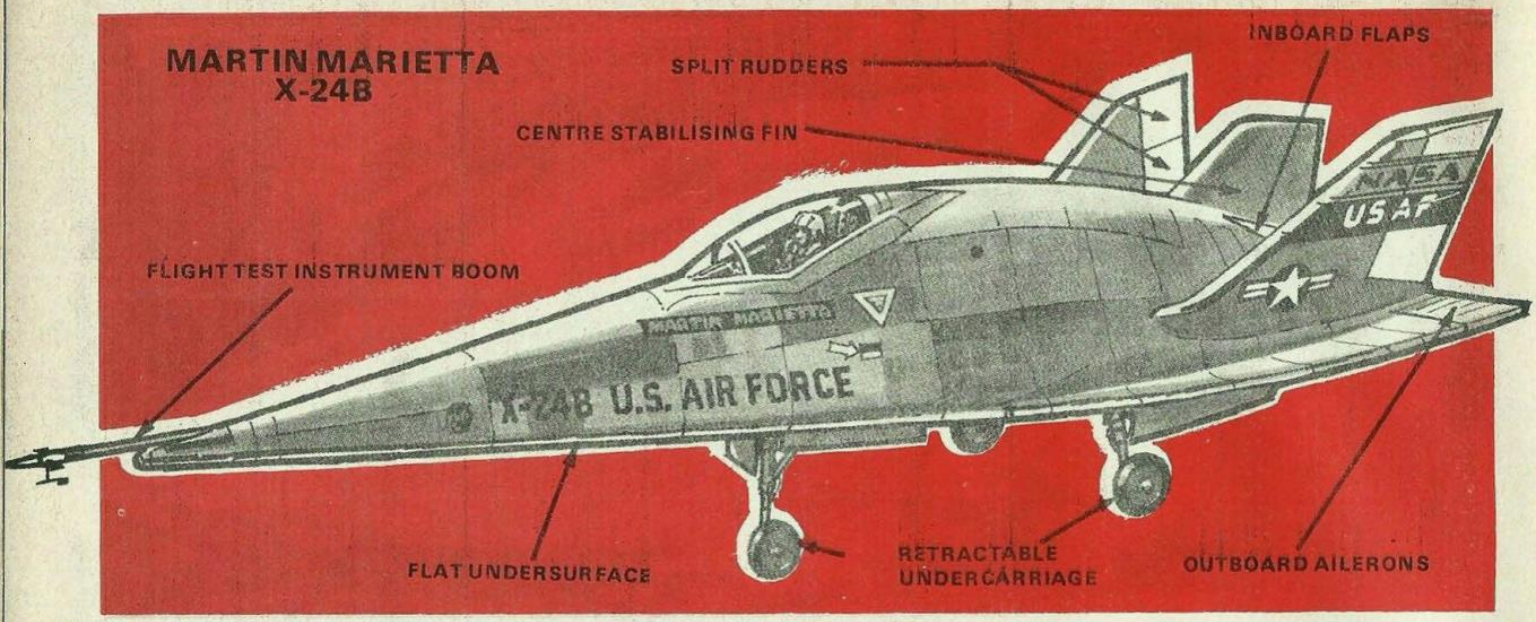
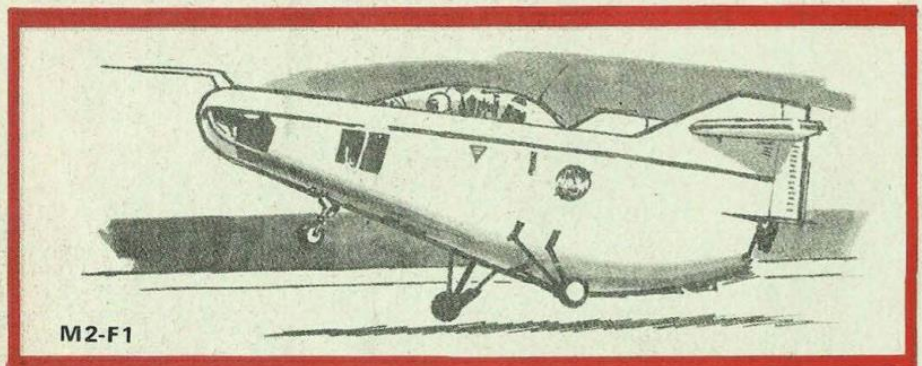
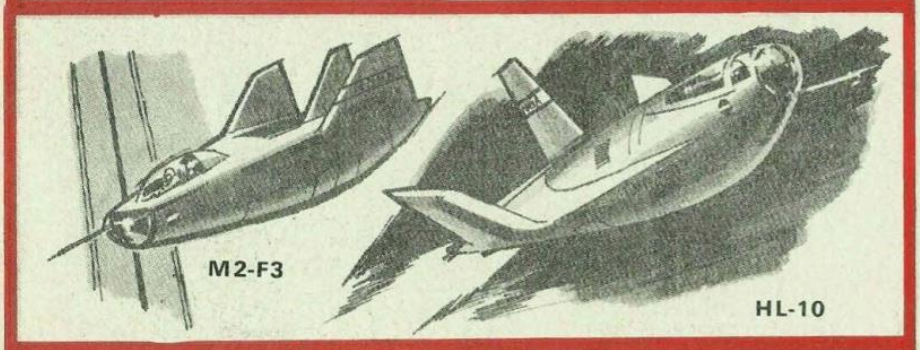
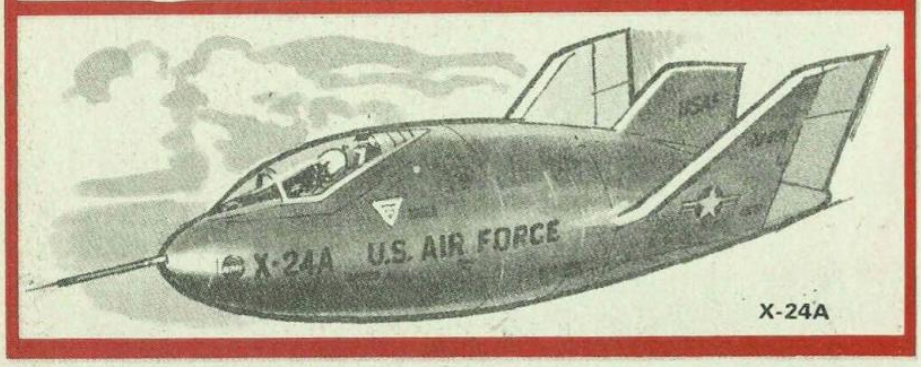





M2-F1





Shaped like bath-tubs and with stubby fins these four " lifting bodies " are a compromise between a shape that can fly very fast and at high altitudes, yet can glide for long distances and remain controllable. The M2-F1 first flew in 1963 and was towed behind the " mother plane ". It was used for studying low speed control. A later model the M2-F2, was fitted with its own power unit and after a landing crash a third ventral fin was added and the craft designated M2-F3. The Northrop HL-10 has carried out a number of flights and reached a speed 1,227 mph. during its powered climb to 90,303 feet after release from the " mother plane." The X-24B is a rebuild of the X-24A. As can be seen the changes are considerable with more prominence being given to a " delta wing " shape to try and improve controllability during the long, shallow gliding descent.

exploration and sub-orbital flight. The design of " lifting bodies " is quite different from conventional aircraft. They must be able to re-enter the Earth's atmosphere at very high speeds or fly at very high altitudes, yet once they reach lower altitudes they must be able to glide and handle well. Because of these unusual requirements the design of a lifting body is always a compromise in shape and presents a great challenge to the designers.

To date every lifting body has been wingless with extremely small control surfaces. The lift for the shallow gliding descent comes from the shape of the fuselage. This has been designed to give the best possible (shallowest) gliding angle and speed with the lowest possible drag (resistance to the atmosphere). The other problem has been to provide the lifting bodies with some sort of control. With no large control surfaces this has been difficult. It is essential for the pilot to be able to change his craft's flight path as it descends through the atmosphere to allow him to glide hundreds and even thousands of miles to his final destination.

HYPERSONIC FLIGHT

The latest in the family of lifting bodies is the X-24B Martin Marietta built for a joint test programme being conducted by the U.S. Air Force and NASA. It is designed to investigate the handling characteristics of future hypersonic aircraft — and possibly re-entry vehicles — in the critical low speed range of their flight from low supersonic speeds, to sub-sonic and landing.

It will be carried aloft under the wing of a USAF/Boeing B-52. When the " mother aircraft " reaches approximately 45,000 feet the X-24B will be released from under the wing and the pilot will ignite the liquid-fuelled rocket which will boost the craft to 60,000 feet and Mach 1.5. The pilot will then glide the vehicle back for landing.

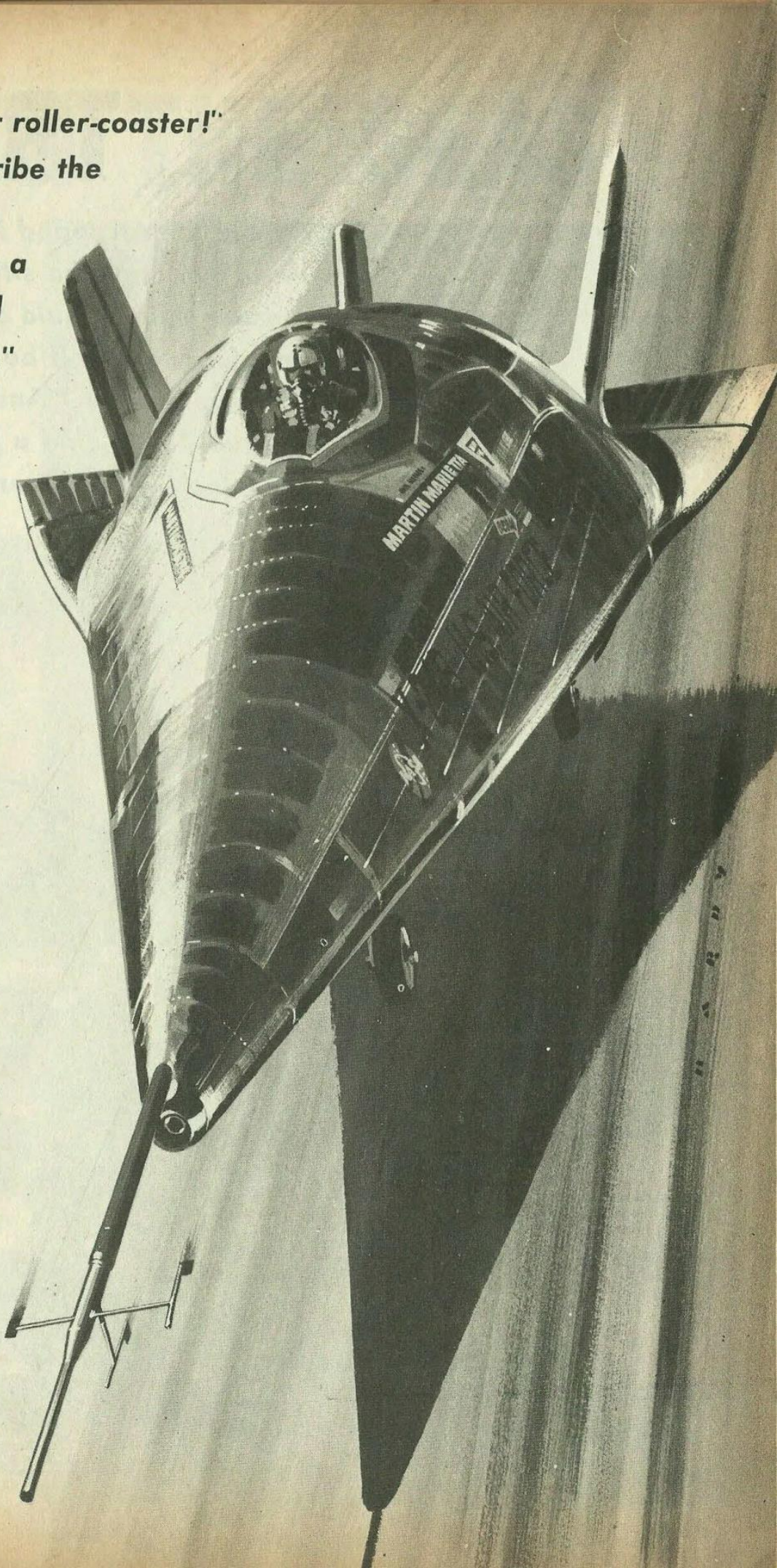
The X-24B is a modified version of lifting body built around the frame of the earlier X-24A. It has a delta wing configuration with three vertical fins and

"It's like riding a super roller-coaster!" That's how pilots describe the rocket-powered climb to high altitudes when a lifting body is released from its "mother plane"

10 different control surfaces for the pilot to alter the flight path. The measure of a lifting body's efficiency is its L/D or Lift/Drag ratio. This measures the distance it flies horizontally against the distance it sinks vertically. The two measurements put together produce its gliding angle which should be as shallow as possible with the best forward speed possible. The X-24B has a lift/drag ratio of 2.5 compared with 1.2 for the earlier X-24A. This means that for every 2.5 feet it flies forward it will sink one foot.

Tests with the X-24B could lead to the development of two different types of vehicle. One would be a high-performance hypersonic craft designed to operate in the Earth's atmosphere. This would probably have an air-breathing propulsion system based on the ramjet principle, where the faster the craft moves through the atmosphere, the more air is fed into the front of the jet engine. The other would be a highly manoeuvrable re-entry craft which would not need a propulsion system and could be re-called from a near-earth orbit on demand and land at any major airport in the United States.

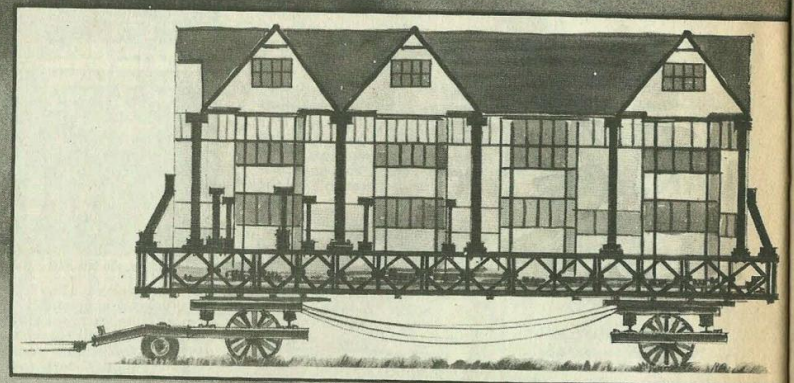
Instruments and computers that will be fitted to such a craft are already being developed. They will compare its height and position with its destination on the ground and give the pilot a continuous flow of information on how he needs to adjust his flight path to reach the desired landing point. This will be vital to the pilot of a craft returning from space with thousands of miles to glide to an accurate touchdown with no help from engine power.

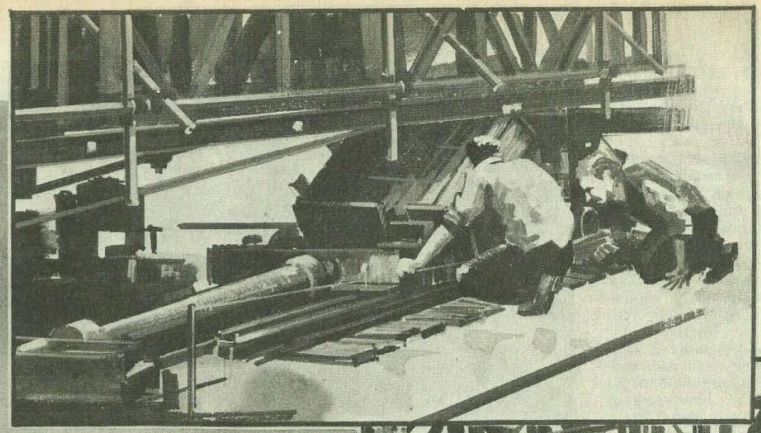


The X-24B coming into land after gliding down from 60,000 feet. This is the sort of flight pattern that a space shuttle re-entering the Earth's atmosphere will have to take, gliding hundreds and even thousands of miles without power to land at a pre-determined airfield.

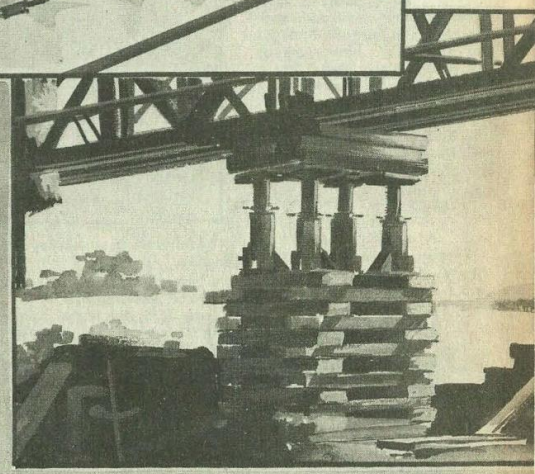
MOVING THE PAST INTO THE FUTURE

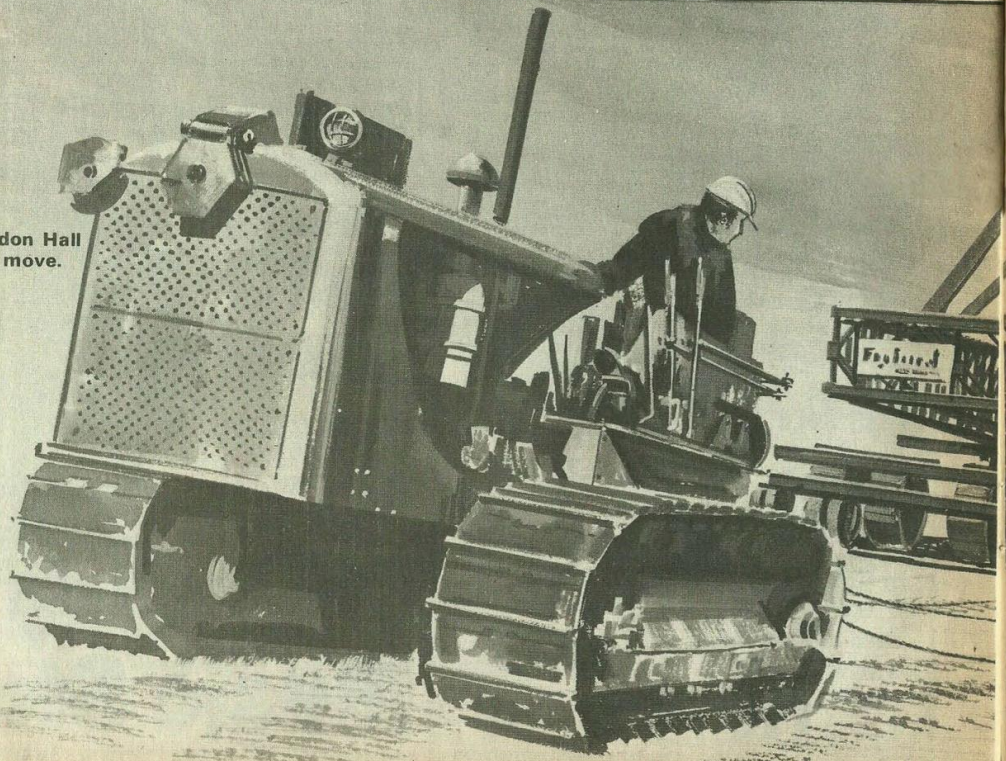
Resting on its new foundations, on a new site, Ballingdon Hall can, once again enjoy its wonderful view of the countryside





Left: Ballingdon Hall moves on wheels. Hydraulic jacks were positioned on each corner of the building (right) and temporary cribbage supports helped in the process of jacking the building up 9 feet 6 inches above ground level (below right).





Ballingdon Hall on the move.

SINCE the days of Queen Elizabeth I's reign, Ballingdon Hall had stood in its grounds near Sudbury in Suffolk, undisturbed and left in peace to enjoy the unspoilt view of the beautiful countryside.

Then, came the threat of the menacing, marching steps of progress in the form of warehouses, and housing estates which, one by one, began to obstruct the gracious mansion's wonderful view northwards over the river Stour.

Its present owner, a solicitor named Mr John Hodge, decided that something would have to be done about this sorry state of affairs, and thought it about time to move house. But, instead of moving from one house to another like most people do, Mr Hodge moved his home — literally — half a mile up Ballingdon Hill.

At the new site, the mansion would be screened by a small

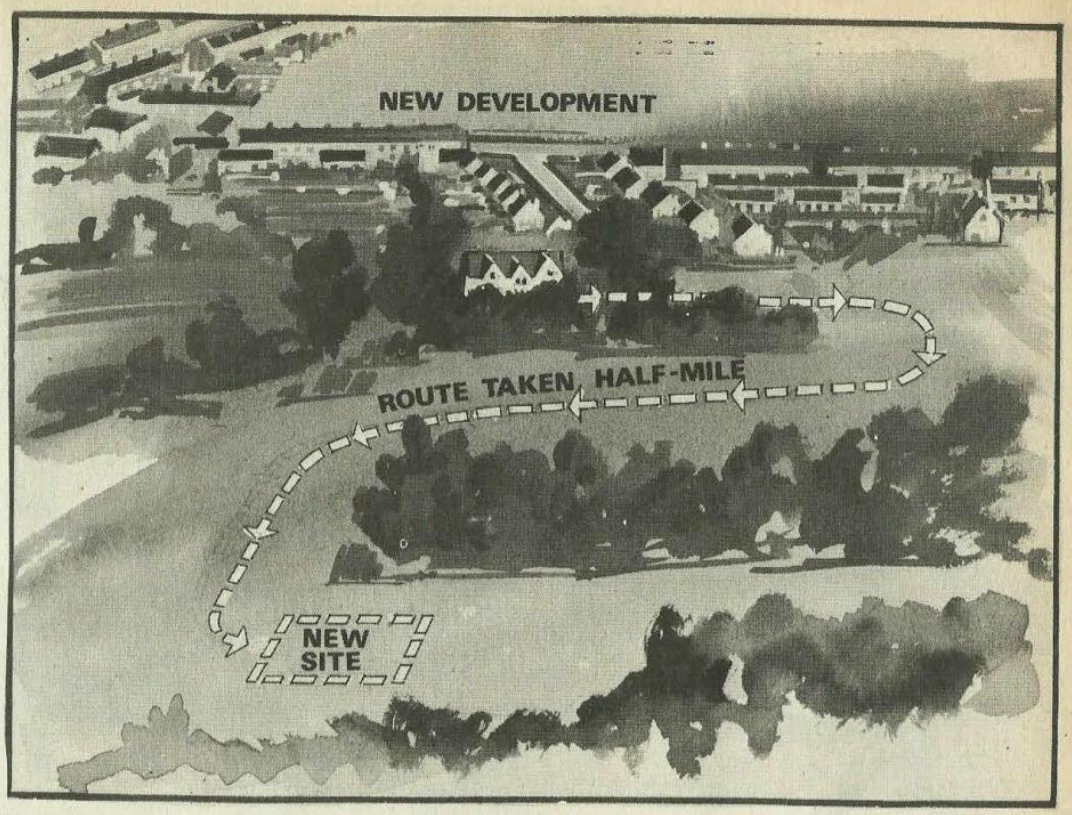
CONTINUED ON NEXT PAGE

copse from the new estate and would have a fine prospect over open country.

But having decided *where* he wanted his home moved to, Mr Hodge then had to decide *how* such a difficult task could be done.

The Government's historic building experts were violently against the idea of dismantling and rebuilding the house because in their experience, this method had always failed. But just when Mr Hodge began to feel that he was asking for the impossible, he heard of a firm who specialises in underpinning foundations of decayed historic buildings. At Exeter and Hereford the firm had already moved two half-timbered houses which had been threatened by redevelopment. And at Knebworth in Hertfordshire they moved a medieval tithe barn through meadows to a new site to provide accommodation for a restaurant.

To prepare for the moving of Ballingdon Hall, the firm launched a complex planning operation to ensure that the house would be able to withstand the move.



The route taken when they moved Ballingdon Hall over a thousand yard forward and up a steep hill.

HAZARDS

The house had to travel a thousand yards forwards and up a gradient of 60 feet. The route it was to take was not a straight-forward one because it had a complicated 'S' shape with tight bends, and rough bumps in the ground surface. All these hazards had to be taken into account when the structural support for the mansion was designed.

First of all, the timber frame of the house was set upon two vast Bailey bridges on which it was slowly jacked up 9 feet 6 inches above ground level. The hydraulic jacks would also be used as a primitive system of suspension, enabling one end of the house to be raised higher than the other to get over the bumps in the ground. The actual wheels were arranged in groups of three, independently moved, which were then joined to form groups of six and each of these groups could be separately controlled.

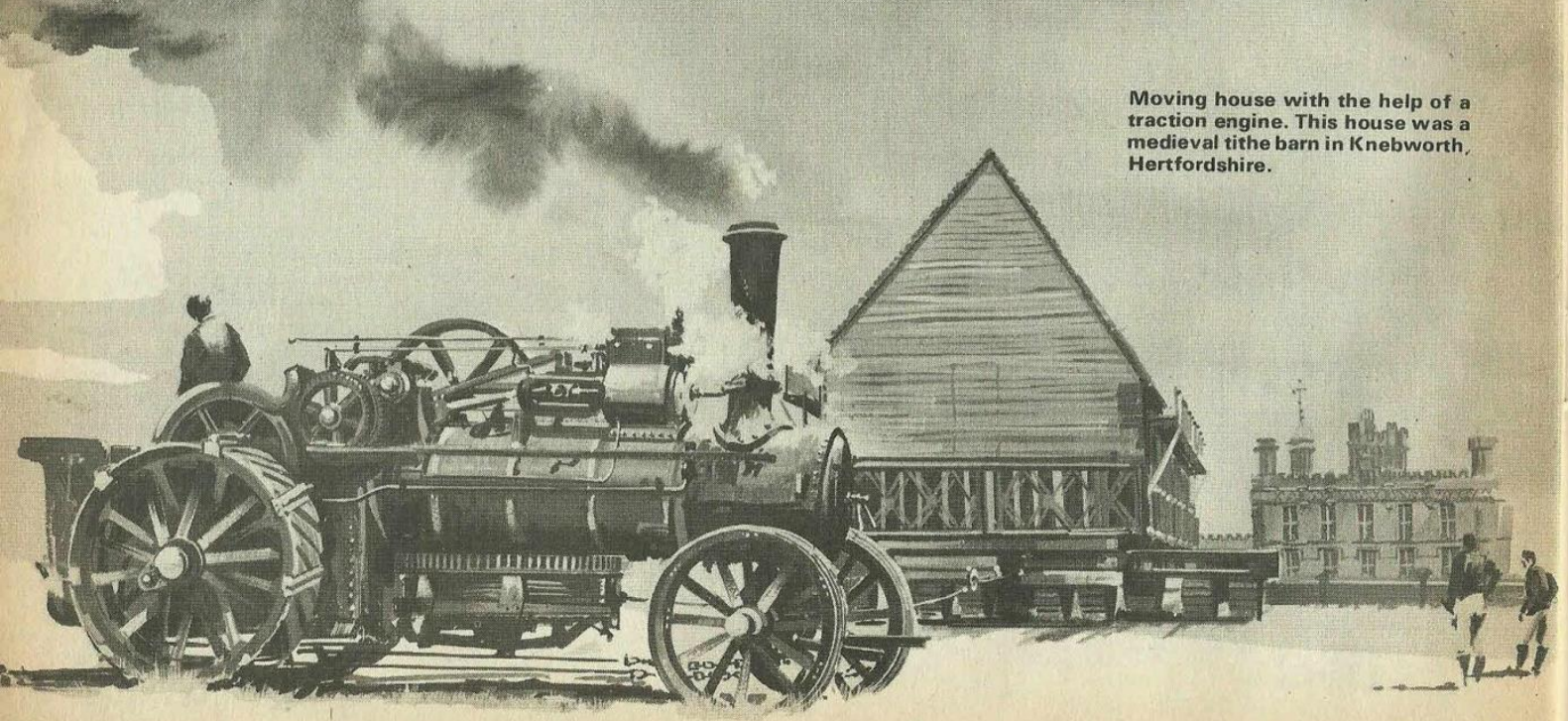
These precautions were absolutely necessary because on the new site is a considerable slope down which the house, having safely reached its destination, could have rolled!

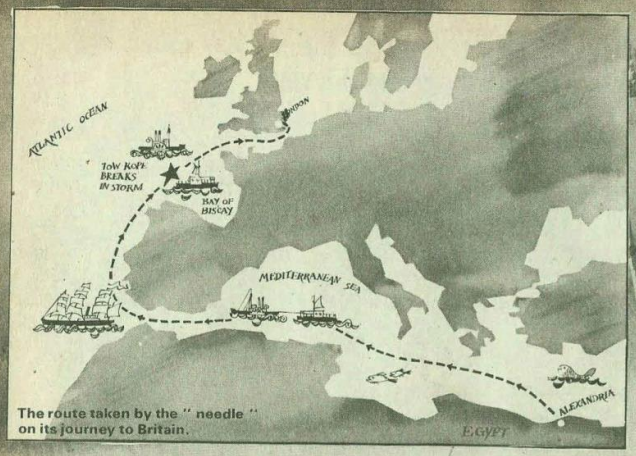
After the completion of these preparations, the physical task of moving the house began. On the 29th of February, 1972, three tractors began to tow the 170-ton, 25-bedroomed house along the carefully prepared route, but after moving four feet, the linkages snapped.

After this unhappy start, the project, which took much longer than originally expected, was eventually finished.

Now, resting on its new foundations, on a new site Ballingdon Hall can, once again, enjoy its unspoilt view of the Suffolk countryside.

Moving house with the help of a traction engine. This house was a medieval tithe barn in Knebworth, Hertfordshire.



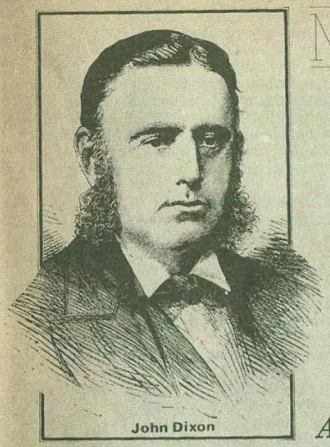


The route taken by the " needle " on its journey to Britain.

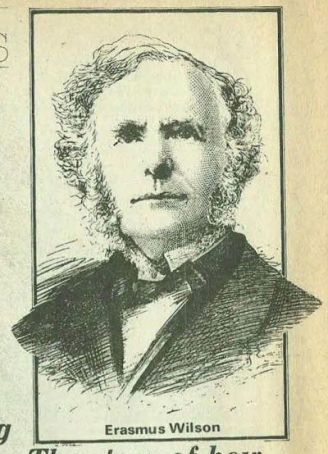
A storm in the Bay of Biscay made " Cleopatra " list so dangerously that she was in danger of sinking. The tow rope was cast off and " Cleopatra " was left to drift.

Monumental Moves

The Saga Of Cleopatra's Needle



John Dixon



Erasmus Wilson

An obelisk built in honour of King Thotmes III stands beside the River Thames in London. The story of how it got to its present site is one of drama at sea and background bickering

TWO PINK granite obelisks lay among the rubbish of a squalid quarter of Alexandria in Egypt. Once they had stood as magnificent memorials to King Thotmes III. The finest of the pair had been made in 1460 BC at Aswan and taken 700 miles down the Nile to Heliopolis.

Here it stood outside the Temple of the Sun as a proud symbol of Egypt's might. Many centuries later, on the orders of Cleopatra, it is said, it was taken down and moved to Alexandria and the Palace of the Caesars.

Napoleon's invasion of Egypt brought the British to the country. They drove Napoleon away. Britain returned Egypt to the Turks, although some British soldiers remained there for a year or so under the command of General the Earl of Cavan.

By now the obelisks had been removed from their former positions and deposited among the rubble of Alexandria's poorer quarter.

But the Earl of Cavan took a fancy to one of them, the finest of the pair. It would, he thought, make a fitting memorial to the British victories in Egypt, if it were shipped to London and erected there as a monument.

The Turks said he could have it. But the Earl's plans to have it shipped to Britain fell through, and he compromised by having a brass plate put on the obelisk. Engraved on this were details of the principal events of the Egyptian campaign. Tribute was paid to Napoleon's valour with a warning that the British nation was ordained by divine providence to defeat its enemies.

Once this had been done the obelisk stayed where it was. Mohamed Ali, one of the local rulers, reminded the British government that the needle was theirs. Would they please remove it?

But the government did not share the Earl of Cavan's enthusiasm for the needle. They accepted the advice of an Egyptologist, Sir Gardner Wilkinson, who said, "It is unworthy of the expense of removal."

The year was now 1868. More than once after this, the Egyptians asked the British to take away their property. Still nothing happened.

Then, a Greek man, who had rented the site on which it lay, said he would cut it up for building blocks.

This made the British realise that if they did not take their property soon, it would no longer be in existence.

To their rescue came a wealthy man named Erasmus Wilson who said he would pay for the cost of bringing the needle to Britain. The government's acceptance of this offer signalled the start of one of the most exciting engineering feats performed by the Victorians.

Their task was to bring the needle, which was 70 feet high and weighed 200 tons, across the seas from its sandy resting place.

The job of doing this was given to General Sir James Alexander, a famous soldier and explorer. He went to Egypt in 1875 to size up the task which had been given to him. To advise him, he had an engineer, John Dixon, who suggested putting the needle into an iron hull, like a tube, and rolling it into

CONTINUED ON NEXT PAGE

Above: the " needle " was secured by wedges within the hull. The " needle " was encased in its hull at Alexandria in Egypt. The hull was made in Britain and shipped to Egypt in segments, where it was reassembled around the "needle." When it was finished, the vessel was named " Cleopatra." It looked like an enormous boiler.

the sea. If it were given a deck and a rudder, it could be towed to Britain, he said.

The strange craft was manufactured in Britain, and sent in sections to Egypt where it was reassembled around the needle. Named " Cleopatra ", the vessel looked, in the general's words, " like an enormous boiler with the ends sloped off."

Pulled by the steamer " Olga " from Liverpool, the " Cleopatra " was towed out into the Mediterranean. The date was the 28th August, 1877. And here fate played a cruel trick. A sunken rock pierced the iron skin. This had to be mended and meant that the journey to Britain could not begin until 21st September.

Had its journey started at the pre-arranged time, the " Cleopatra " would have been clear of the Bay of Biscay before an Atlantic cyclone struck it on 14th October. As it was the " Olga " and its strange trailer, ran slap into the worst storm to hit the Bay of Biscay since time immemorial.

" Cleopatra ", which carried rails as ballast, began to list so dangerously, that she was in danger of sinking and dragging the " Olga " after her.

There was one obvious solution, and this was acted upon. The tow rope was cast off and " Cleopatra " was left to drift.

She carried a small crew, and six men put out from the " Olga " in a small boat to rescue them. But the storm was so severe that the men from the " Olga " were drowned.

And there was a further disaster. Amid the raging waves, " Cleopatra " vanished. Howls of rage went up in London. Those who felt that the whole expedition was an example of folly, and felt that the needle itself was not worth the effort and the loss of lives, had many supporters.

However, the expedition which seemed ill-fated from the start, was to have a better ending. A Glasgow steamer found the iron cocoon, containing the obelisk which King Thotmes had so admired, some days after the storm had abated and towed it to El Ferrol. A ship named " Anglia " went to collect " Cleopatra " and bring it to Britain.

It was brought to Southend and towed up the Thames to West India Export Dock.

Having got the obelisk, Britain did not know where to put it. Some suggested that it should be set up outside the Houses of Parliament. But this was turned down.

Finally the needle was erected on the Victoria Embankment, London, beside the River Thames, on 12th September, 1878. In the pedestal at its base were placed a number of objects which will intrigue future generations.

When some demolition expert in years to come takes down the monument he will find a surprise package containing the following: The Book of Genesis in Arabic, a railway guide, a razor, a box of cigars, hairpins, photographs of a dozen pretty women and a portrait of Queen Victoria.

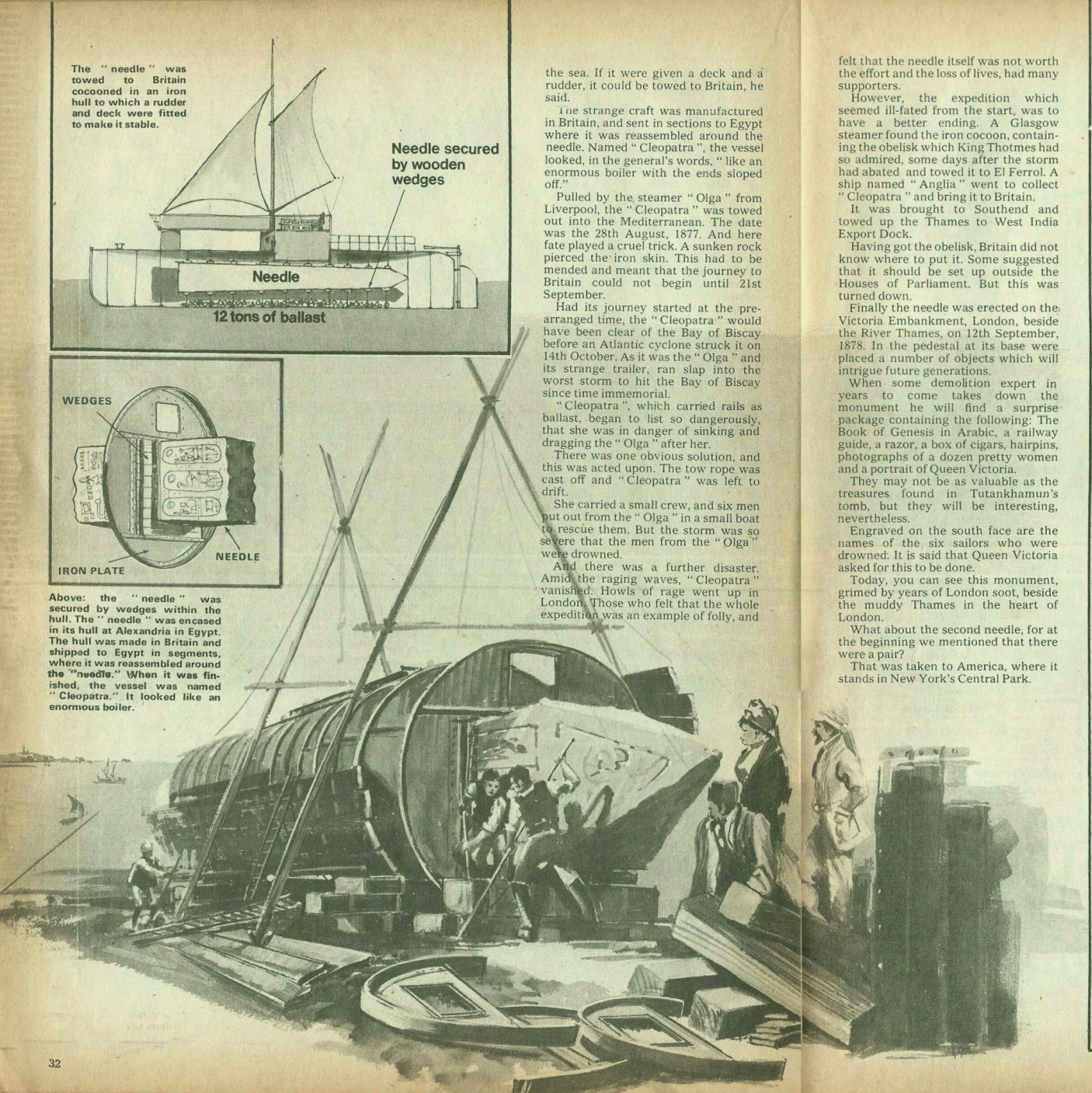
They may not be as valuable as the treasures found in Tutankhamun's tomb, but they will be interesting, nevertheless.

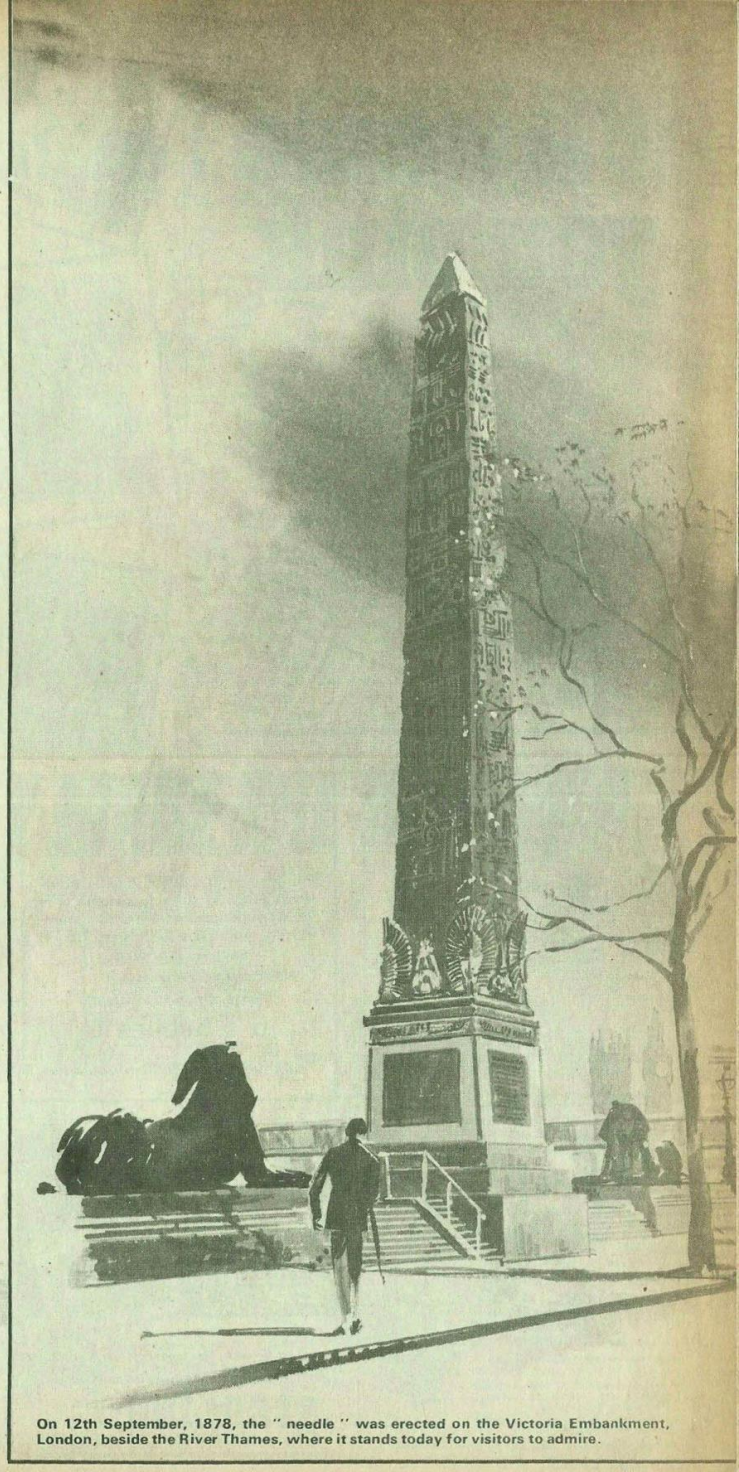
Engraved on the south face are the names of the six sailors who were drowned: It is said that Queen Victoria asked for this to be done.

Today, you can see this monument, grimed by years of London soot, beside the muddy Thames in the heart of London.

What about the second needle, for at the beginning we mentioned that there were a pair?

That was taken to America, where it stands in New York's Central Park.





On 12th September, 1878, the " needle " was erected on the Victoria Embankment, London, beside the River Thames, where it stands today for visitors to admire.

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THE GETAWAY CAPSULE

SEE INSIDE

Fire blazes on an oil rig. But the oil men are escaping to safety in a space age lifeboat.

Modern Marvels

SPLASHDOWN TO SAFETY IN A SPACE AGE CAPSULE

A strange spacecraft-shaped capsule may save the lives of a new type of seafarers—the men who spend their working lives on oil rigs far from the coasts

THROUGHOUT recorded history, the sea has been a savage enemy of Man. It has taken its merciless toll of ships and lives. Yet, undeterred adventurers have crossed it in search of new lands, pirates have plundered on it and men have delved beneath it to explore the world of the ocean depths.

Men are still braving it today. Even the astronaut who visits the Moon must return to the sea in a capsule that bobs on the water until the rescuers arrive.

Just such a capsule may save the lives of a new type of seafarer — the men who spend their working lives on oil rigs far from the coasts.

Danger can come in many forms to these men. A storm may make their rig unsafe. Fire may break out. Treacherous weather may even topple the rig from its sea-legs.

A quick get-away system is vital, and the capsule you see on these pages should provide this.

It is called the Brucker Survival Capsule and it is made from a special fibreglass reinforced plastic that resists fire. There is room inside for 28 people with enough air for them to breathe for an hour.

In a matter of seconds, it can be launched from a single point without powered assistance.

The men simply board the capsule on the launching platform. One line lowers the capsule to the sea. The descent time from 65 feet is just half a minute.

The capsule splashes down evenly without swamping or floundering in heavy seas.

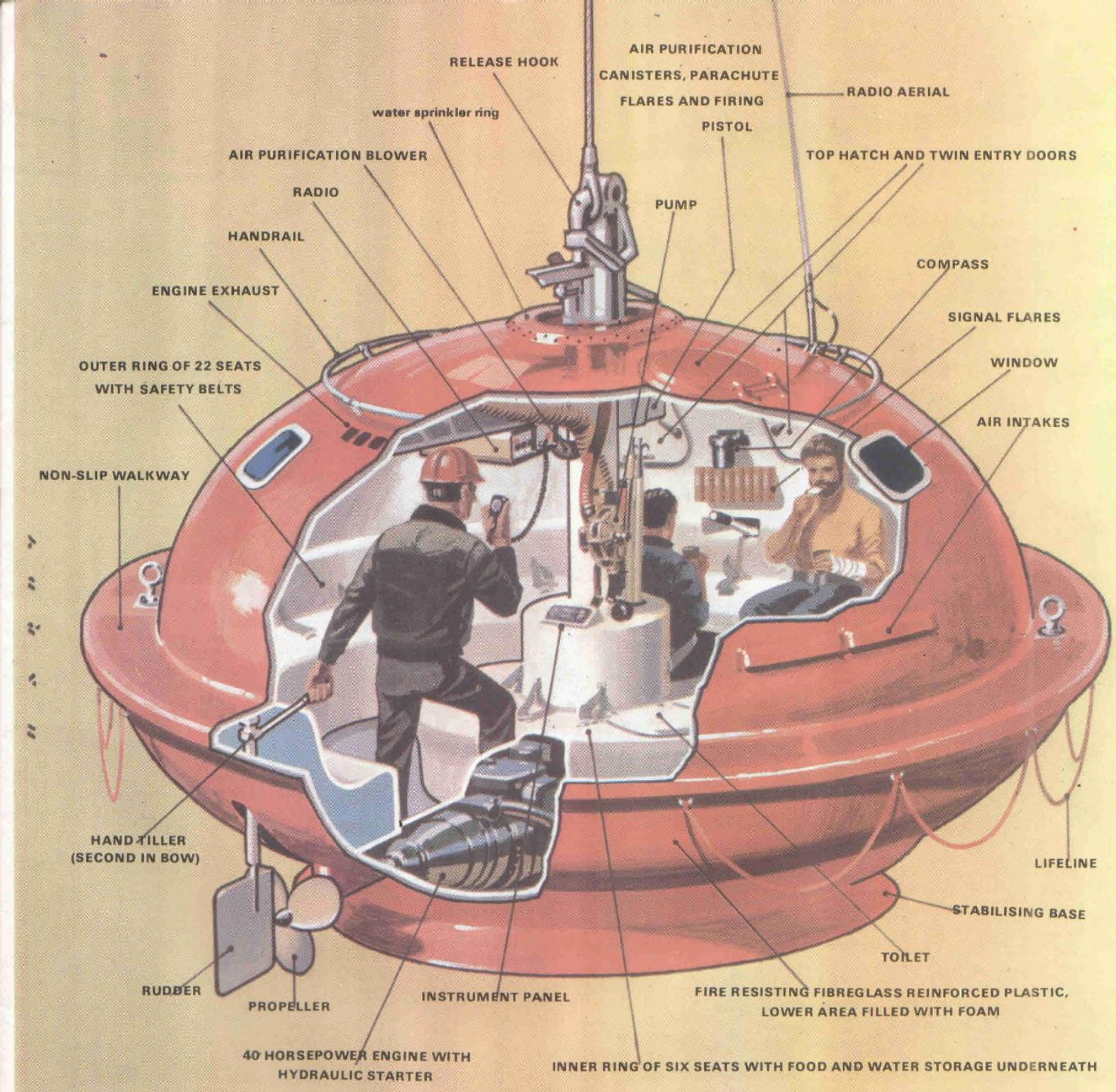
Once in the water, the crew take off for safety. A 40 h.p. diesel engine propels the capsule at speeds of up to five knots.

There is enough food on board to keep them alive. And while they are heading for the shore they can fire distress signals to call the lifeboat services.

Already, this system is in use at 250 oil rigs throughout the world. The crews on these are oil men, not seamen. In an offshore emergency they need a simple-to-use system that gets them off the platform quickly and away from danger safely.

Clearly, the men have confidence in the system, for one of the most important aspects of survival at sea is confidence in the vessel's life-saving equipment.

Reports from many tragic sea disasters show that crews stay with stricken vessels too long. One of the reasons for



This cutaway drawing shows some of the main features of the capsule. Fully loaded, it seats 22 people on the outer ring of seats and six on the inner ring.

this is that practice fire drill cannot always be followed through to the complete abandonment of the ship.

But this is possible with the capsule system. Crews can practice escaping from danger, because the capsule can be lowered to the sea and then winched back on board the oil rig.

The equipment consists of the holding and launching platform. This is welded to the rig, from which it projects and suspends the capsule above the sea.

No power is required to lower the capsule to the sea. To raise it to the platform after a life-saving drill, an electric winch is fitted, rated for 11,000 pounds working load.

This means that it has plenty of capacity in reserve to raise the capsule, which weighs about 5,000 pounds with all its equipment.

The dome has a radar reflective surface, so that it can be found more easily by ships searching for it with their radar equipment.

Radio can be included for sending out S.O.S. messages, and for this same purpose there are signalling mirrors, distress flares and a whistle.

The capsule is approximately 14 foot in diameter and nine foot high.

It contains a toilet, watertight food and water storage compartments and compartments for tools, survival equipment, battery, engine, bilge pump, fuel tank, lighting, instrumentation, air purification and exhaust systems.

They make this capsule a far cry from the traditional lifeboat that has changed little during the last hundred years or more.

Yet, as early as 1883, a capsule design was patented. While the idea was sound, it was not possible for it to be developed because suitable materials were not available.

It remained for present-day experts, with the new space-age materials and knowledge, to make such an idea a practical reality.

They have brought confidence to the men whose lives are spent on the lonely oil rigs amid turbulent seas.

MORE MODERN MARVELS ON THE NEXT TWO PAGES

Invisible dangers lurking in wartime harbours may be traced by a helicopter-sleuth that sweeps the seas for hidden mines.

FINDING THE OCEAN'S HIDDEN KILLERS

INVISIBLE rays traced a network of danger across the entrance to a harbour. They came from magnetic mines so placed that any ship which came near enough to them would trigger off a devastating explosion, great enough to obliterate the unsuspecting vessel.

Situations like this are common enough in wartime, when harbours and sea-lanes are mined with a variety of hidden killers. There are mines which are exploded by the sound from a ship's motor. Others are mechanical mines which explode when struck by a ship. Yet others become balls of death when a passing vessel alters the pressure of the water. And, again, there are the magnetic mines which shatter when a ship's natural magnetism comes into the field of magnetism made by the mine.

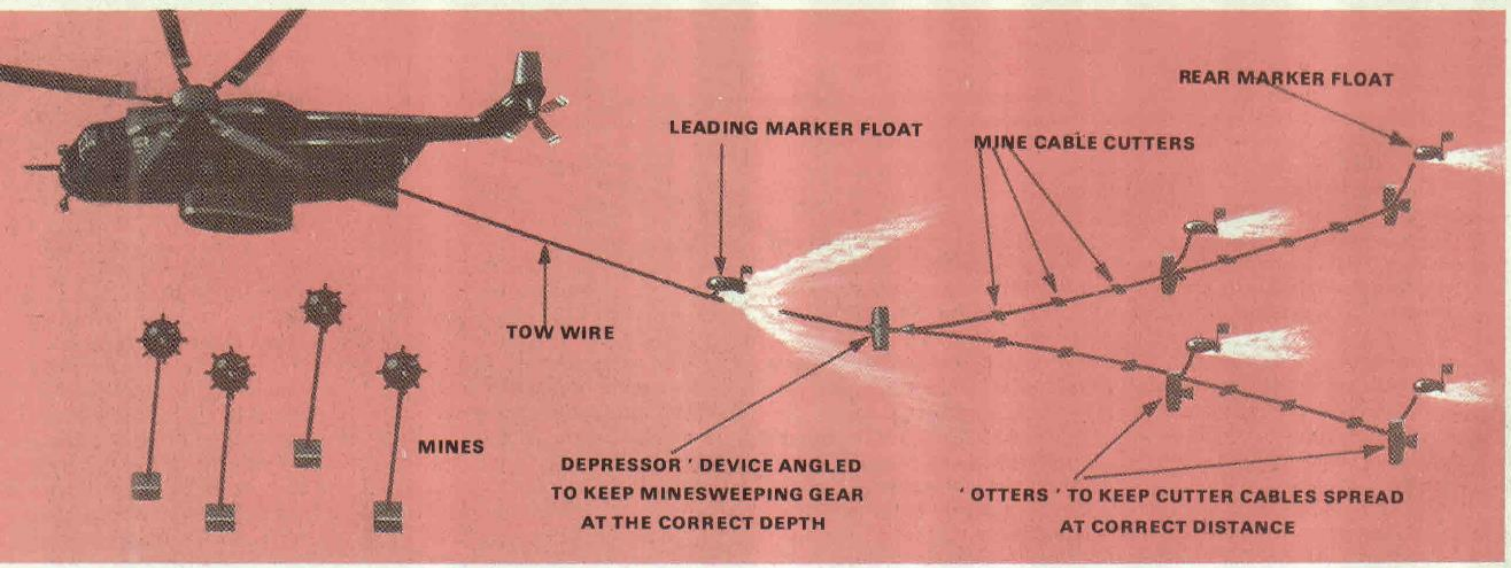
To clear the sea of mines in the conventional way involves the uses of ships' towing gear which is intended to explode the mines. But the ships doing this are themselves in danger.

To overcome this, the Americans have developed the helicopter you can see on this page. It is the Sikorsky RH-53D which has been designed to tow equipment through the water to set off the mines and make the sea safe.

So versatile is the towing equipment, that it can imitate the magnetic field of a ship to find magnetic mines. And when searching for acoustic mines, it tows a device that makes a sound like a ship's motor to cause mines which respond to this to detonate.

Another method is to tow cutters on cables that fan out behind the helicopter. When they find a mine's mooring chain, they cut it. Gunfire destroys the mine when it bobs to the surface, and the menace under the ocean is there no more.

Here is America's new mine-sweeping helicopter. In this picture it is towing gear for finding magnetic and acoustic mines. The diagram below shows the equipment used for finding mechanically detonated mines.



THE TRAIN DRIVER IS A COMPUTER

LIGHTWEIGHT electric trains are speeding through twin tunnels under the waters of San Francisco Bay in America at speeds of up to 80 miles an hour. They run on a new railway system which carries people to work from San Francisco, which is bounded on three sides by water, to the mainland.

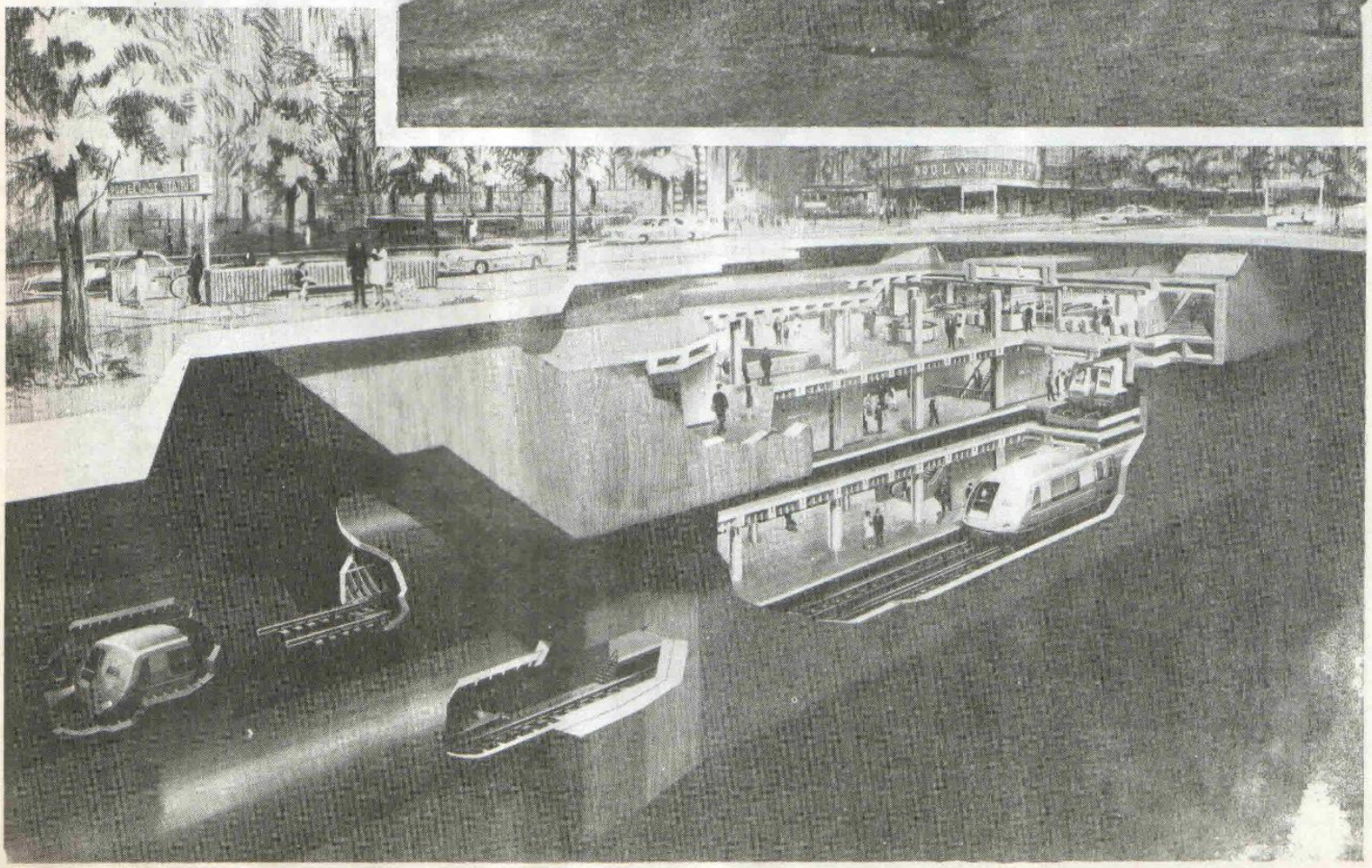
Its name is the Bay Area Rapid Transit System, popularly known as BART, and it gives people a quiet, fast and smooth ride in computer-controlled trains with wall-to-wall carpets, seats shaped to fit the human body and air conditioning.

Computers send the sleek trains around their circuit at intervals of 90 seconds. They anticipate peak loads, marshal and route the trains and adjust the speeds of those that deviate from the schedule.

One engineer-attendant rides on each train, but only to take control in an emergency.

Twenty-eight miles of track were opened last September, and all of the 75 miles of the network should be carrying passengers by the end of the summer.

San Francisco's new railway runs on an elevated track (above) and below ground level (below). It also runs under the water of the bay to link San Francisco, on a promontory of land, with Oakland on the mainland.



ALL AT SEA

Men are solving some of the ocean's mysteries and fighting the terrors of the sea with the inventions shown on this and the following pages

FLOATING ISLAND

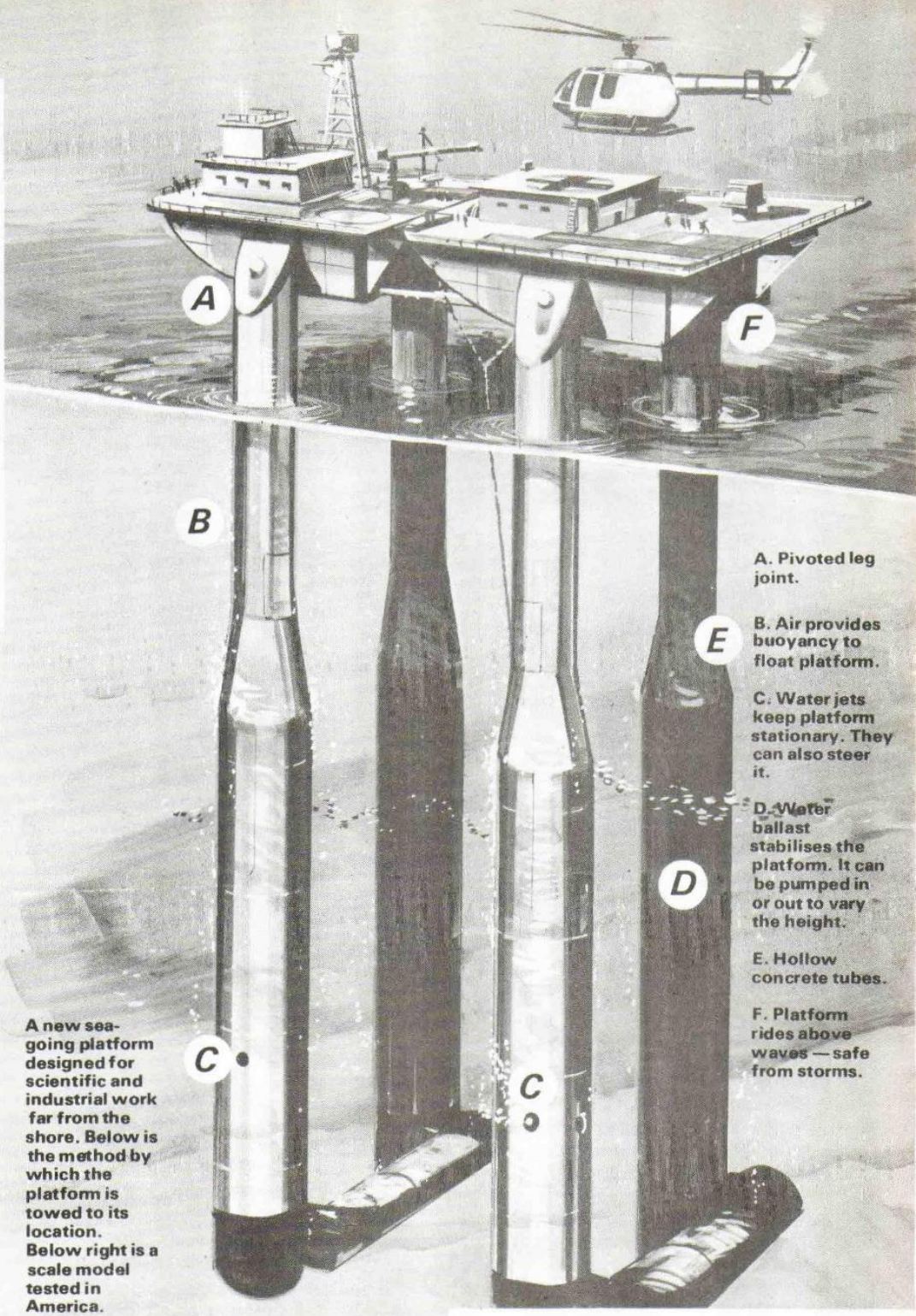
TWO, partly-hollow concrete legs hold the secret of a new sea-going platform which can be used far offshore for scientific or industrial work.

Because they are pivoted (A), they can be filled with air (B), and made to provide buoyancy when the platform is being towed to its position. Once at sea, they are filled with water ballast (D) to stabilise the platform (F) which rides above the sea, safe from storms.

Water can be pumped in or out of the legs to vary the platform's height, and may be forced through the jets (C) to keep it stationary or to steer it. Hollow concrete tubes (E) also help to keep the platform buoyant.

The rig is designed to be towed out to sea in two sections (as shown below) and then joined. The pivoted legs float empty until in position. Then they are submerged to lift the platform clear of the surface.

Together, the sections provide an area of 15,000 square feet, or about one-third of an acre. Additional rigs could be added to make a floating island of virtually unlimited size.



A new sea-going platform designed for scientific and industrial work far from the shore. Below is the method by which the platform is towed to its location. Below right is a scale model tested in America.

A. Pivoted leg joint.

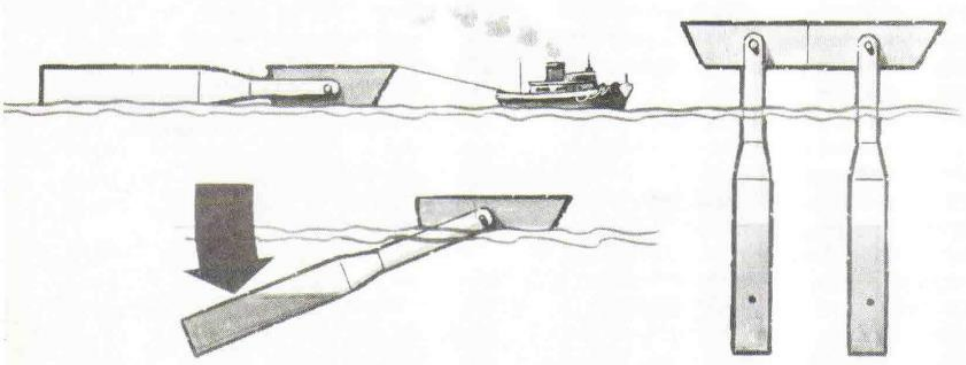
B. Air provides buoyancy to float platform.

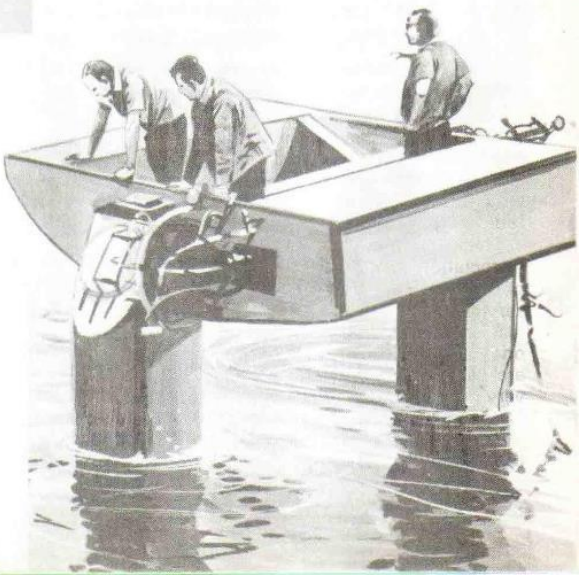
C. Water jets keep platform stationary. They can also steer it.

D. Water ballast stabilises the platform. It can be pumped in or out to vary the height.

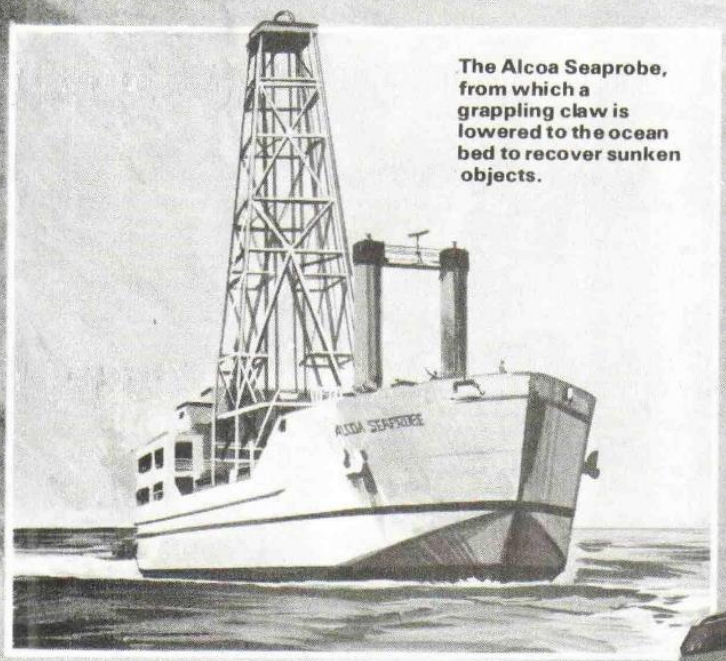
E. Hollow concrete tubes.

F. Platform rides above waves — safe from storms.

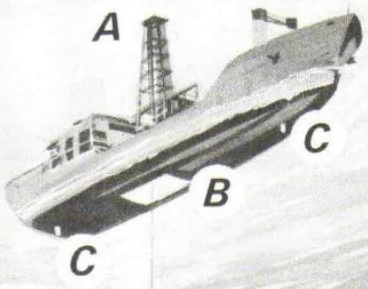




ALL AT SEA



The Alcoa Seaprobe, from which a grappling claw is lowered to the ocean bed to recover sunken objects.



A. Derrick tower. B. Well in bottom of hull. C. Fore and after stabilising propellers. D. Propulsion unit for manoeuvring the claw. E. Searchlights. F. TV camera. G. Grappling claw.

LONG RANGE SEA CLAW

A GAPING hole opens up in the bottom of the ship's hull and a giant spider-like claw plunges down into the ocean depths to pluck some sunken object off an otherwise unreachable sea floor.

Called the Alcoa Seaprobe, the new 243 foot long, all-aluminium research vessel shown here is designed to do what no man or machine has yet been able to accomplish — to recover lost treasure from antiquity, sunken ships and scientifically valuable ocean-bottom samples lying far below the working range of divers and conventional salvage equipment.

Its 102 foot tall derrick tower is capable of lifting 200 ton loads from depths of up to 6,000 feet — more than a mile.

It can also bring up core samples from as far down as 18,000 feet — nearly three-and-a-half miles.

Searchlights and TV cameras are fitted to the claw, so that the operators on board can direct it on to the chosen object, which can be pulled up into a large centre well for close study, by the scientists on board the ship.

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No. 590. 5th MAY 1973
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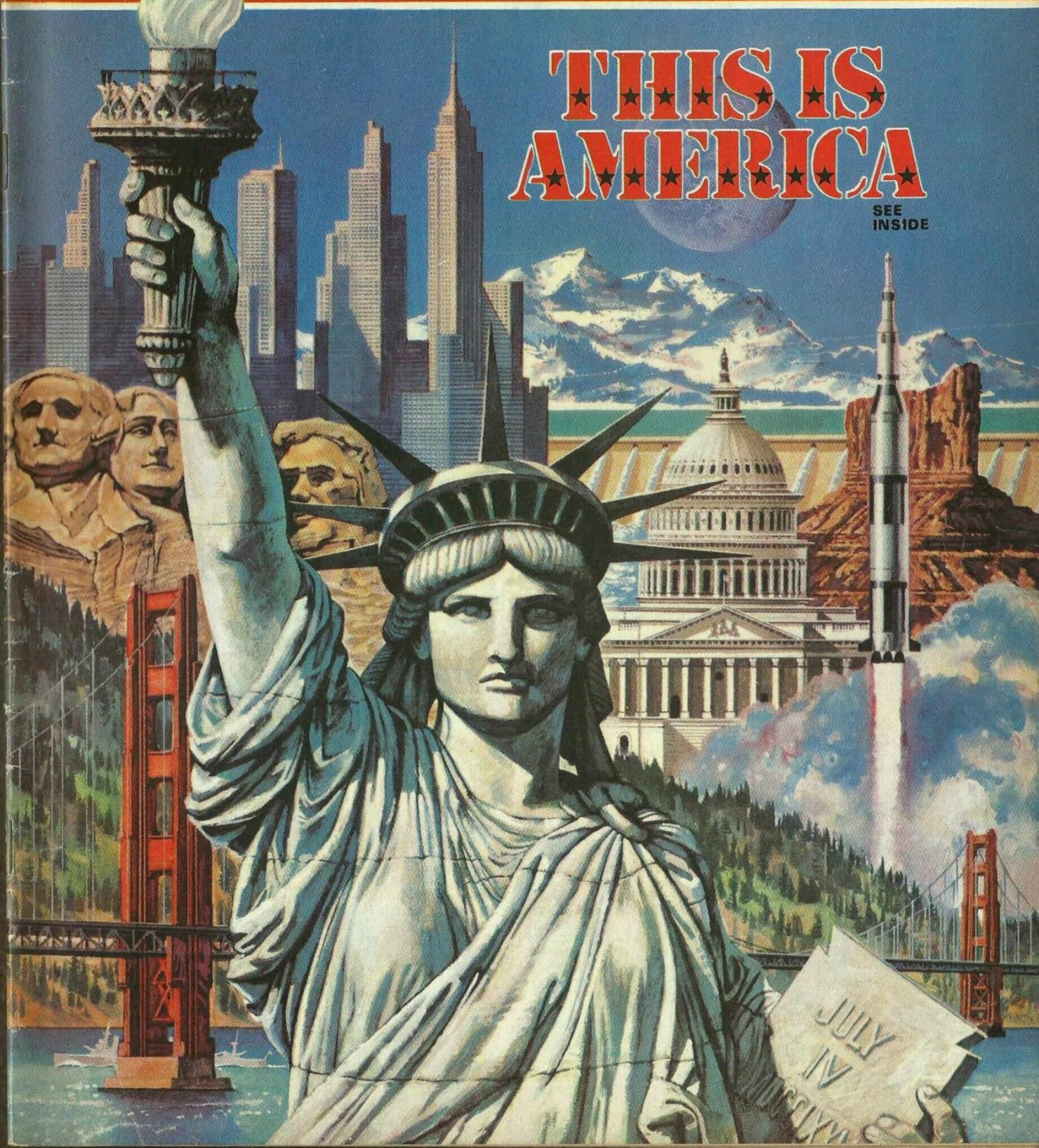
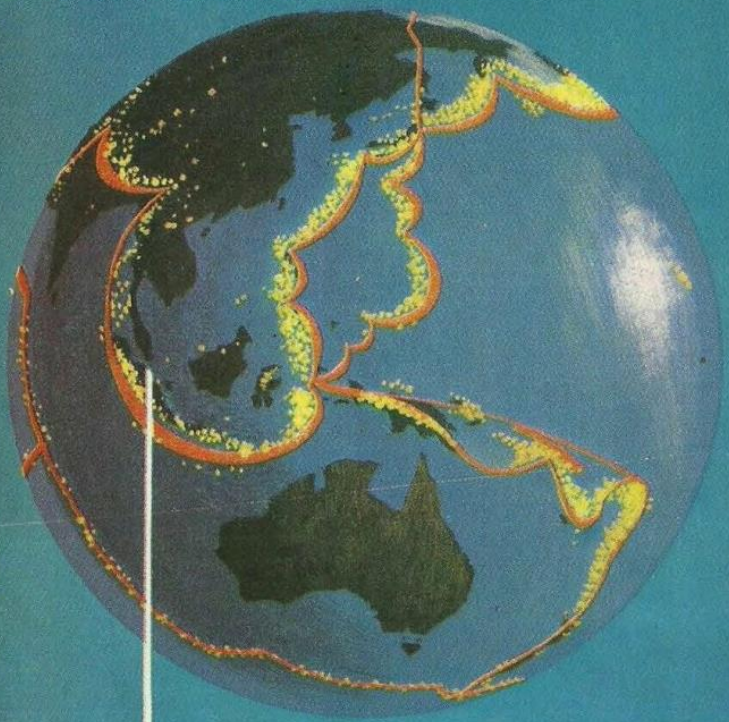
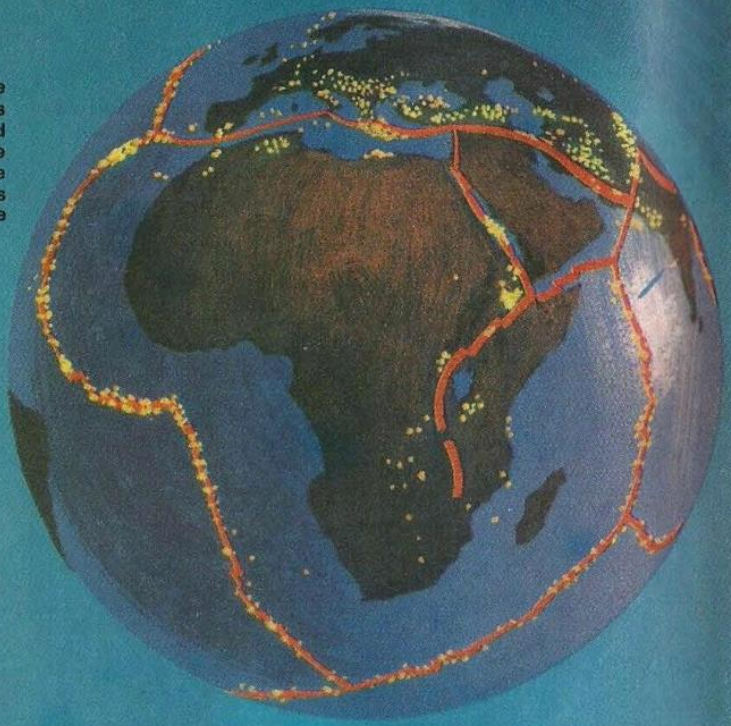
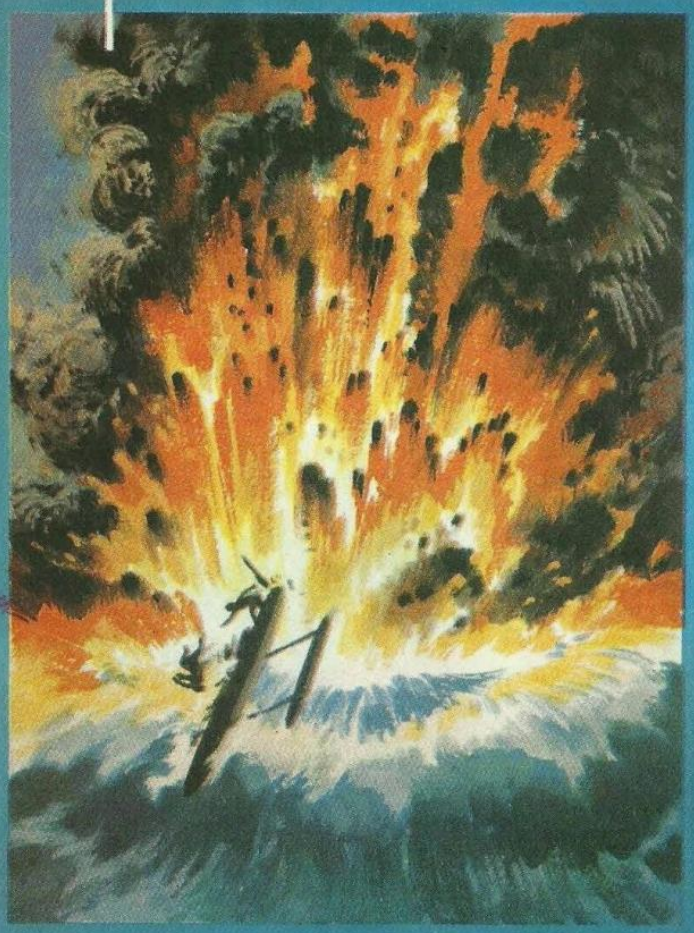


These three faces of the Earth illustrate the way in which the surface crust of our planet is composed of irregular-shaped plates. The red lines show where the edges of these plates rub, grate, stick and slip over and under each other. The yellow markings show recent earthquake activity, areas of weakness in the crust which mark the plate boundaries. One of the most terrible of modern earthquake disasters is shown below — the awesome volcanic explosion which obliterated the island of Krakatao in 1883.







WHEN CONTINENTS COLLIDE

Trying to predict and control an earthquake could be a very tricky problem. So far the best advice the experts can give you is to try and be somewhere else when it happens

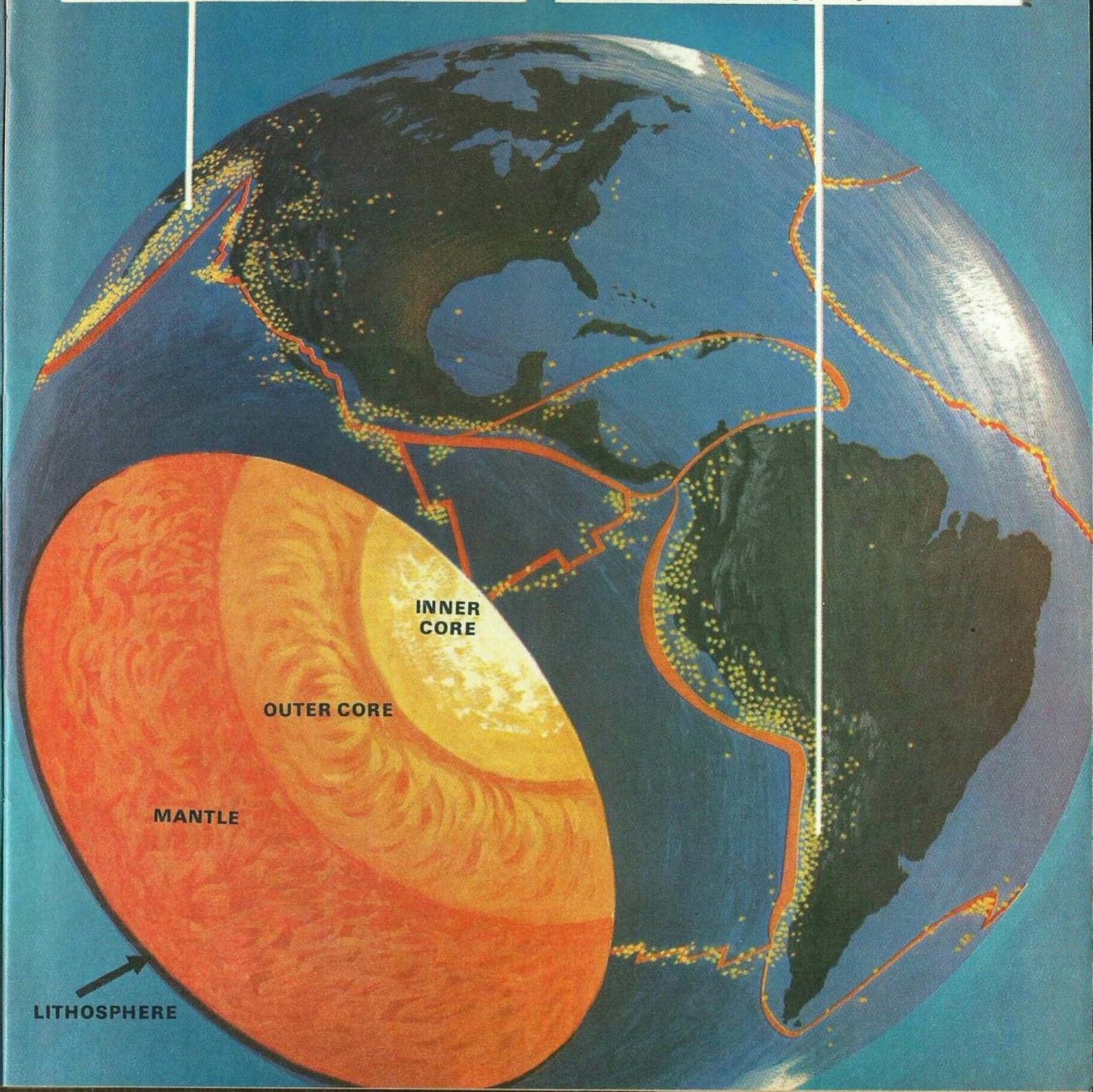
THE Earth is old. As near as we can reckon, it was formed 4,500,000 years ago. It was then a huge jagged mass of rock with a fiery core, enveloped by a dense gas cloud. Gravity worked upon it, pulling the raw rocks and dust together, moulding them into a sphere. Again and again the heat of the core would burst through the skin of the sphere, breaking and dissolving it. Water condensed from the gases expelled by the melting rocks, and the first rains fell. Very gradually, the surface of the sphere began to cool and harden.

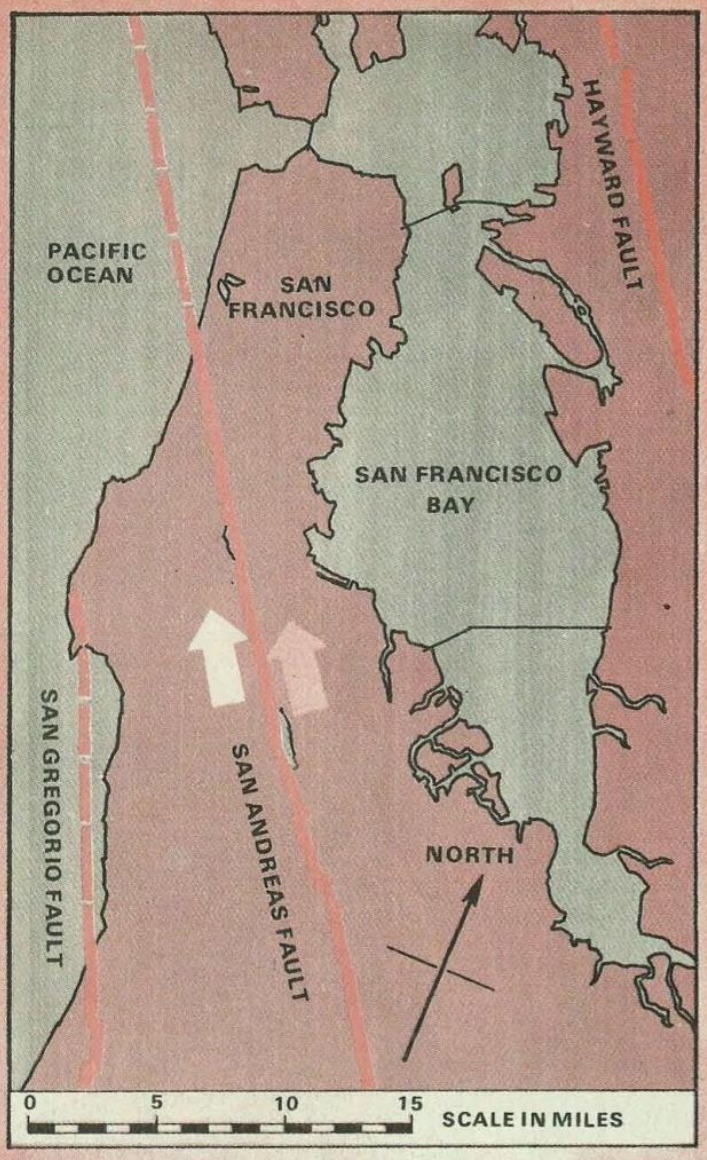
We are a long way from that

CONTINUED ON NEXT PAGE

On March 27th, 1964, Alaska was hit by a shattering earthquake which flattened towns and raised giant " tsunami " sea waves that swept inland, adding to the havoc.

In May 1960 an earthquake triggered off an avalanche in Peru which loosened mountain snow, rocks and other debris that swept down the Santa Valley at 300 mph, demolishing the village of Yungay with great loss of life.





Slowly but surely the world's great land masses are on the move, grinding and grating past each other with unimaginable force that only reveals its presence when a catastrophic earthquake flattens a city or a volcano erupts in molten fire

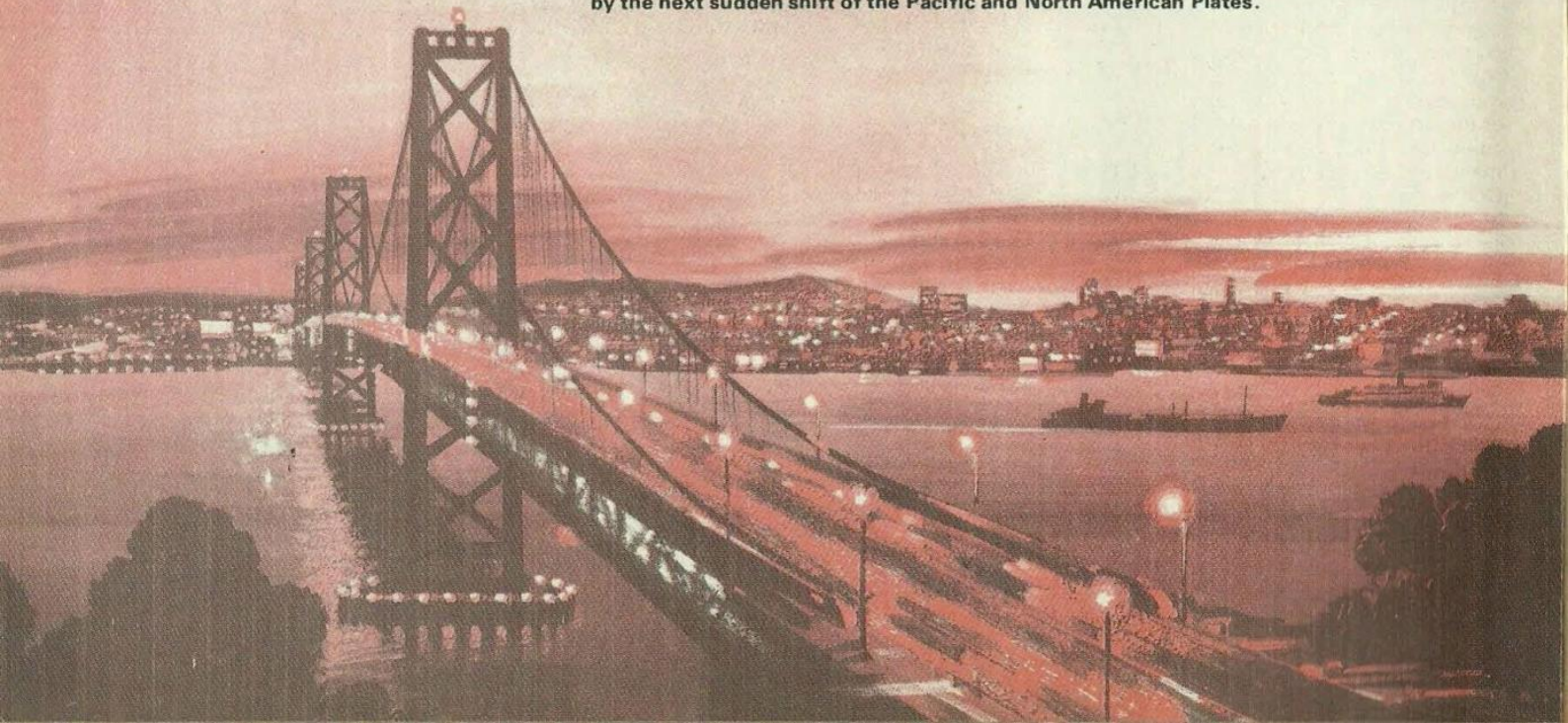
fiery beginning. If a ruler one yard long represented the time between Earth's formation and today, the whole story of man, from semi-ape to space-traveller, would occupy the final one-fiftieth of an inch. Seen from space, the world is a ball patterned with cool blues and greens overlaid with white swirls of cloud. It looks peaceful and permanent. A closer look reveals that it is neither of these things. Beneath the seas and continents, the fires are still burning. The surface of the Earth continues to change, and the most dramatic signs of change are volcanoes and earthquakes.

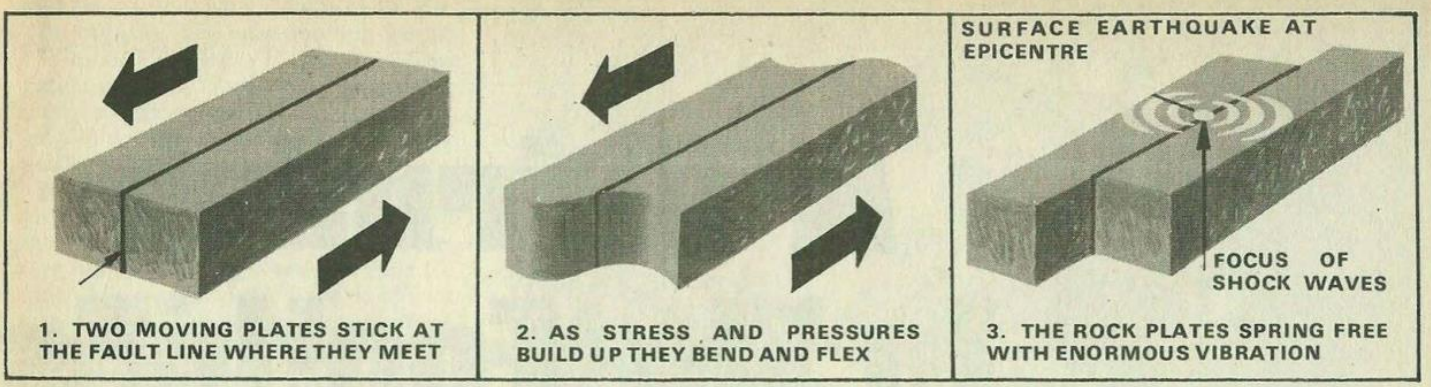
DEVASTATION

The fury of a major earthquake is difficult to imag .e. Britain experiences only the mildest of tremors. In Chile, on the Pacific coast of South America, an area of land as large as Devon and Cornwall combined sank six feet in less than a minute, during the earthquake of May 22nd, 1960. Off the coast, the sea rose above the high-tide line as the sea-bed heaved and shook. Three enormous waves rushed inland at speeds up to 120 miles per hour, sweeping away houses and ships, and scattering villages up against the hills like driftwood. Far from the sea, among the Andes mountains, landslides swallowed entire farming communities. Rivers were blocked and forced into new channels. Roads disappeared. Railway bridges were smashed. Eight thousand miles away, in London's quiet Kew Gardens, seismologists' instruments registered the most powerful shock ever recorded.

That was only one incident in the long history of earthquakes. Across the Pacific, the Japanese capital, Tokyo, was destroyed in 1923 along with Yokohama and many other

The famed San Andreas Fault which threatens heavily-populated San Francisco and its surrounding area. The plate on the Pacific Ocean side (White arrow) is moving north-west at a much faster rate than its neighbour (red arrow), building up enormous stresses. In 1906 it suddenly slipped 20 feet, causing colossal damage. Smaller 'quakes have since occurred and scientists say that the area is due for another big one any time now. Below: The Bay Bridge which crosses from Oakland to San Francisco. Unless some means of controlling the San Andreas Fault can be found this area could be obliterated by the next sudden shift of the Pacific and North American Plates.





towns. The dead numbered 150,000. A huge wave, or tsunami, sweeping hundreds of miles south from a shock which shook the Aleutian Islands at the tip of Alaska in 1957, struck the shores of Hawaii and caused extensive damage. San Francisco was devastated by the great quake of 1906, probably the most famous disaster in American history. It is no coincidence that these, and thousands of other shocks, occurred along a well-defined curve which encloses three sides of the Pacific Ocean, or that the same curse is studded with volcanoes.

FIERY LIQUID

Under the rocky crust on which we live lies the lithosphere, the tough shell of the Earth. Scientists now believe this shell to be composed of approximately 20 plates, or sections, fitted together in jigsaw fashion. Below them is the dense and fiery liquid of the mantle, surrounding the massive metal core of the planet. Like vast stone rafts, the lithosphere sections float upon the surface of the mantle, jostling and grinding against each other as the currents move them. Where two or more plates collide, mountains rise, volcanoes erupt, and earthquakes shatter cities. One such meeting-place marks the edges of the Pacific Ocean.

DANGER SPOTS

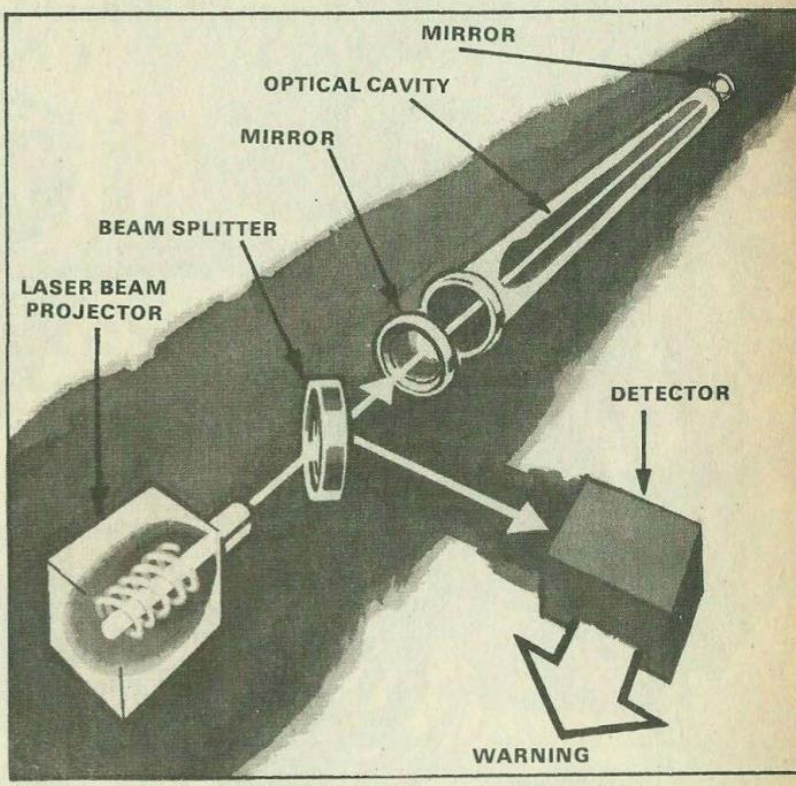
Plate tectonics, the study of the lithosphere, is helping us to understand the forces which generate earthquakes. More recent work by Soviet and American researchers has revealed that vibrations in the earth caused by small, harmless shocks begin to slow down shortly before a more powerful shock occurs. It is not yet known why the speed of these vibrations changes, but it could provide a warning of coming danger. Unfortunately there is more to the business of saving lives and property, than merely predicting the exact time of a major earthquake. Cities in some areas of the world have been flattened not once but several times, in past centuries, and still the survivors rebuild them upon the same sites. A man who persists in pitching his tent across the path of an express train cannot be saved by a railway timetable.

The reasons which anchor people to such danger spots are often economic. Farmers cannot afford to leave areas of fertile soil. Outside of the cultivated land there may be barren desert, mountains or dense jungle. Many earthquake victims are poor and ill-educated peasants, unable to adapt to other ways of life. Yet the most thoroughly examined earthquake area in the world, and the one for which a great disaster is most frequently predicted, lies in America's richest state, California.

PREVENTION

Cutting across the lower south-western half of California is the San Andreas Fault, the border between the Pacific Plate and the North American Plate. The Pacific Plate, almost as large as the ocean it supports, is moving north-westwards at roughly two inches per year, grinding along the edge of the American continent. Carried along with it, southern California is being torn away from the rest of the United States. This is not a smooth, continuous movement. For long periods the two immense sections of lithosphere are locked together. Stresses build up along the fault. The rocks bend and twist under the enormous forces at work upon them. Suddenly the stress becomes too great. The rocks give way, releasing pent-up energy as they snap back into shape. And the land around the fault shudders and cracks.

Above: How an earthquake is born. Below: A laser strain meter which measures the motion of two opposing plates. A laser beam is projected over a great distance across a fault. Any movement of the plates causes interference of the pattern of laser light inside the optical cavity and this is relayed via the beam splitter into the detector.

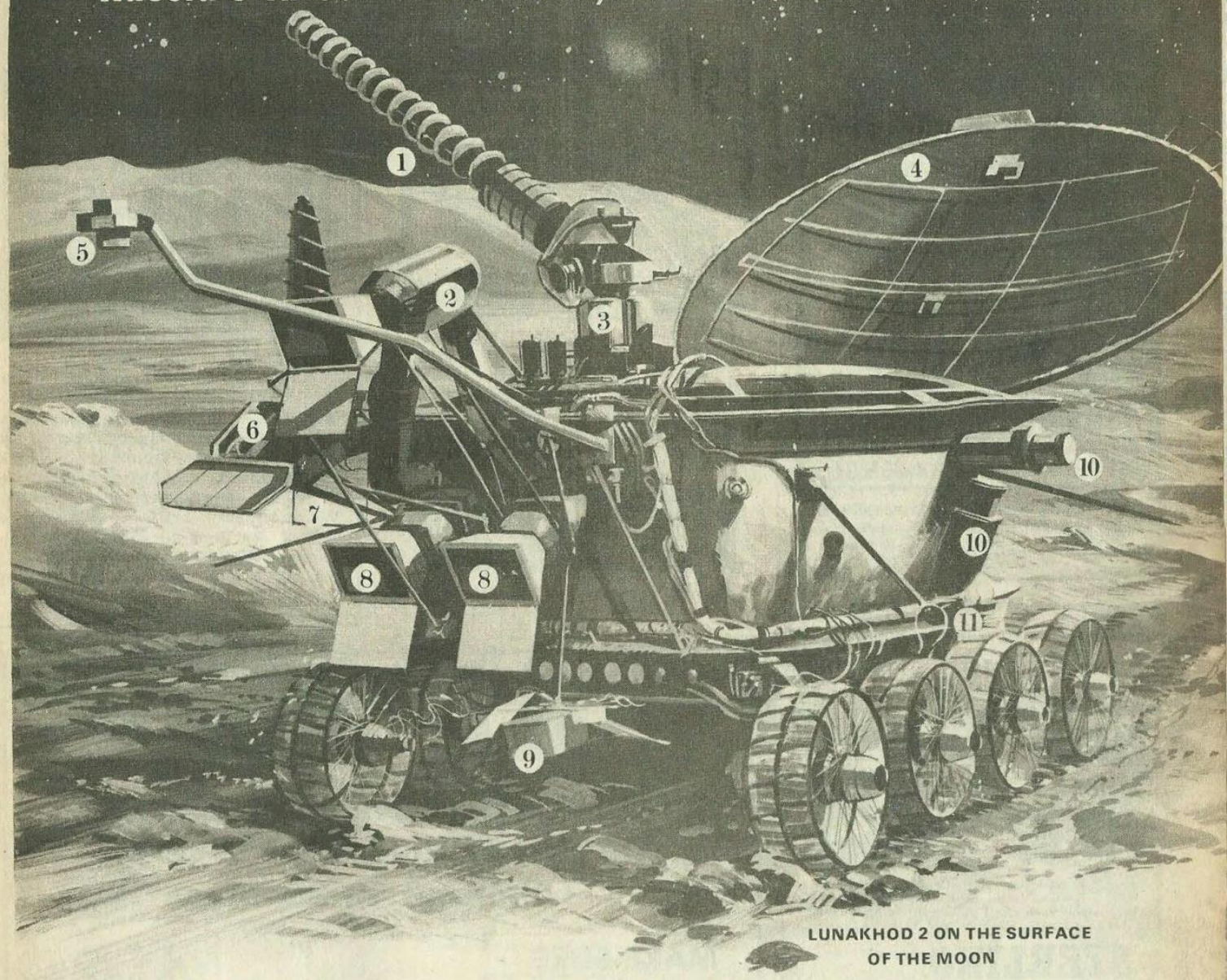


Los Angeles lies on the coast of southern California, within the San Andreas region. It is a city unlike any other in the world, a sprawling monster over 40 miles wide, crammed with automobiles and incredible buildings which seem to be already halfway into the 21st century. Many people have forecast disaster for Los Angeles before the end of the present century, but there is little that can be done about it. The city is big and rich and complicated, the home and workplace of millions of Americans. It cannot pack and move away like a gypsy camp.

The only salvation for Los Angeles and other cities in similar situations is to prevent the earthquakes from taking place. So far, there have been very few practical schemes devised. One which seems to offer some hope involves setting off explosive charges at the points where stress is building up. By doing this before the stresses reach a dangerous level, the man-made shocks may induce the quake to release its power in a series of small bursts instead of one destructive convulsion. It has also been suggested that a fault could be lubricated with a specially prepared mud or slurry, so that the two rock-faces would slide smoothly across each other instead of locking together. Much more research has still to be done on both of these proposals. Meanwhile, the best answer to earthquakes is to be somewhere else when they happen.

THE ROBOT ROVER

Russia's latest lunar robot, marvel of remote radio-control



LUNAKHOD 2 ON THE SURFACE OF THE MOON

(1) A movable antenna used to pick up the command signals from Earth. (2) A high-mounted television camera for producing panoramic views of the lunar landscape. (3) Command signal receiver. (4) Solar battery which is charged by Sun's light. (5) Magnetometer for study of Moon's magnetic field. (6) Laser reflector which will be used by American, French and Russian scientists for Earth-based laser experiments. (7) Stellar photometer for the study of ultra-violet and infra-red light sources in the Milky Way. (8) Stereoscopic cameras which transmit pictures to the operators on Earth who are responsible for manoeuvring the Lunakhod. (9) Soil analysis equipment. (10) Solar photometer. (11) Soil mechanics sounder.

LIKE a large, multi-wheeled bathtub with a confusing array of taps, the latest Russian robot rover trundles across the lunar landscape in a world of its own. It is a masterpiece of remote-control for the hands that guide it are 240,000 miles away in Russia, commanding the rover by radio-signals to turn right or left, to go forward or back.

Somewhat overshadowed by the American manned-landings on the Moon, Russia's space programme has nevertheless advanced steadily and has concentrated on the use of robot vehicles for its own exploration efforts. The latest rover to be landed on the Moon is Lunakhod 2. It is heavier than its predecessor and carries a high-level television camera for sending back landscape views as well as a variety of equipment for carrying out experiments to do with the structure of the Moon and for studying the stars further out in space.

The robot rover was carried to the Moon by Luna 21, a space ferry craft which touched down on the surface in January this year. The control of the retro rockets was so successful that the shock absorbers functioned in only one of the legs to soften the touchdown.

After checking out the rover's main systems and surveying the surrounding Moonscape with television from atop the lander module, the rover descended on to the surface, controlled by its Russian operators on Earth. Stereoscopic television cameras with wide-angle lenses transmit a picture of the area in front of the rover back to the operators so they can plan and control its movements. Even so this remote control is not easy. At one point the Sun was at a high angle, foreshortening all shadows and it became so difficult for the Earth-bound operators to judge distances that they almost ran the rover into its landing stage by accident. Fortunately the error was noticed in time and when the robot was but a few feet away from a collision a turn was executed.

In later excursions Lunakhod was driven nearly three-quarters of a mile over the lunar surface and made soil analysis experiments with the spectrometer.

The present range of robot equipment now appears to be the mainstay of Soviet lunar exploration plans. The machines have proved reliable and versatile and future Russian plans may include a stationary robot lunar laboratory that can carry out a broad range of experiments over a long period of time, all controlled by radio-signals from Earth.

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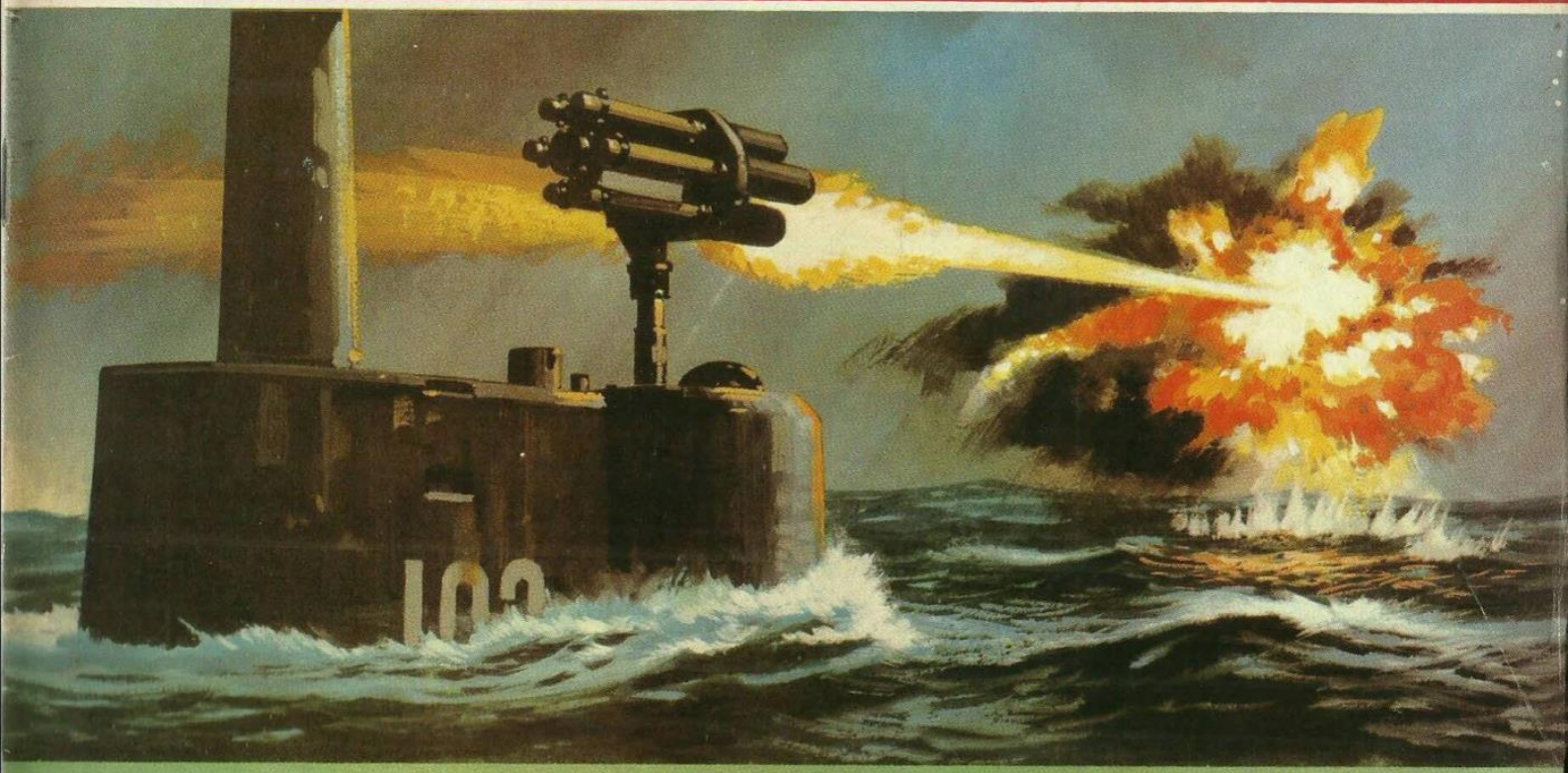
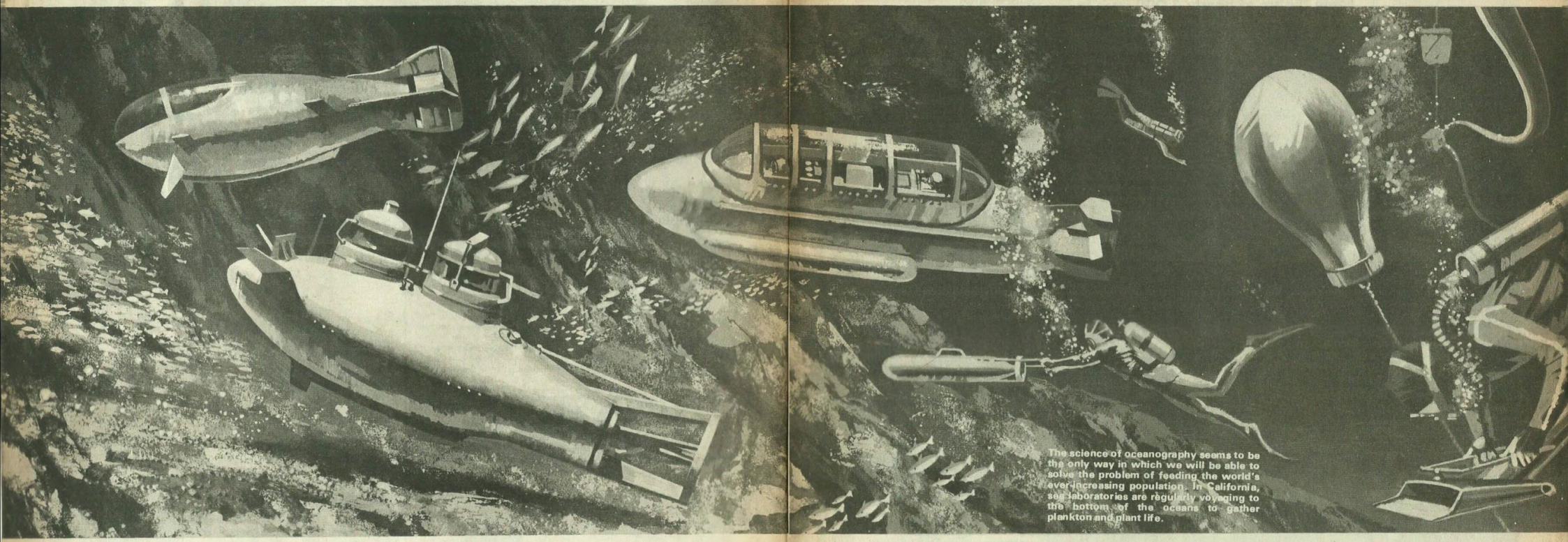


'BLOWPIPE' STRIKES BACK

See Inside

Send A Robot-Not A Man

See Inside



The science of oceanography seems to be the only way in which we will be able to solve the problem of feeding the world's ever-increasing population. In California, sea laboratories are regularly voyaging to the bottom of the oceans to gather plankton and plant life.

This Is America

A BLUEPRINT FOR THE FUTURE

Probably nowhere else will the way of life in the year 2,000 be so advanced as in the United States which has progressed rapidly in a very short time. But before its technological advances are achieved, America must first combat many of the grave problems that confront her

IN the year 2,000 — only just over 25 years ahead — the world will be so different that there will have to be a major change in the way of life we know today. Probably nowhere else will the technological revolution be so advanced as in the United States of America. Their truly magnificent achievement in space in the last decade will have made many unbelievable inventions possible. Landing men on the moon has cost the Americans over ten thousand million pounds. Now, in the foreseeable future, there are to be no more moon explorations. Because of this there are many brilliant scientists out of work. They will have to find other outlets for their great knowledge. At present many of them are working in garages, supermarkets, or mending washing machines.

All Western countries seem to be going through a different kind of revolution, bloodless, but nevertheless very dangerous to the free world. In Britain we are in the middle of an industrial and economic revolution. America has other serious problems to combat — racial hatred between black and white, pollution on a tremendous scale, and appalling crime in the cities.

In Los Angeles last year there were nearly 350,000 crimes. Many families buy protection as there is a burglary every 12 seconds in the U.S.A.

In Los Angeles 400 families have built a small town which can be compared with the forts that were constructed to protect them from the Indians in the frontier days. The Los Angeles experiment is not an isolated one. These fortress towns have an electrified 8 foot wall with guards at the entrance, all armed with guns. Alsatian dogs with their handlers are on the alert, and are in touch with each other and the local police force by walkie-talkie radios. Machine guns and riot control gas are on hand 24 hours a day. Ultrasonic beams are in operation — these invisible rays set alarm bells ringing if anyone walks through them. Closed circuit television is used so that you can see who is at your front door.

In Harlem, the negro quarter, one can feel the racial tension. No white man wanders through these squalid streets alone. The armed police, with their alsatian dogs, always patrol in pairs.

The pollution in New York and Los Angeles is becoming impossible to live with. In Los Angeles, perhaps the worst city in America for pollution, the government have put forward a proposal to impose petrol rationing to try to end the notorious smogs.

UNDERSEA SEARCH

Many Americans believe that the petrol driven motor car will be abolished by the year 2,000. It should then be possible for all cars to be propelled by electric motors which will be powered by minute batteries. Cities will either become free of traffic, or vast underground shopping-only streets will be built under them.

American scientists are worried that the world will not be able to grow enough food to feed the ever increasing population. Just as the exploration of the moon and planets has been pioneered and the most unbelievable science fiction stories are coming true, so man's knowledge and control of marine life is being rapidly increased by the science of oceanography — the exploration and exploitation of the seas. Unlike the land, most oceans are unexplored and cover three-quarters of the earth's surface.

In California, sea laboratories, similar to submarines, are regularly voyaging to the bottom of the oceans, gathering specimens of plankton and plant life. The oceanographer knows that the supply of animal protein can be increased ten times with more efficient harvesting of the seas, and they believe that the search for food under the sea must succeed, because in about 30 years' time there will be six billion people in the world — that's two for every one today.

Again, the vast experience that the Americans have obtained from their moon and space explorations will alter commercial flying. Research has already started on the possibilities of building a hypersonic vehicle which

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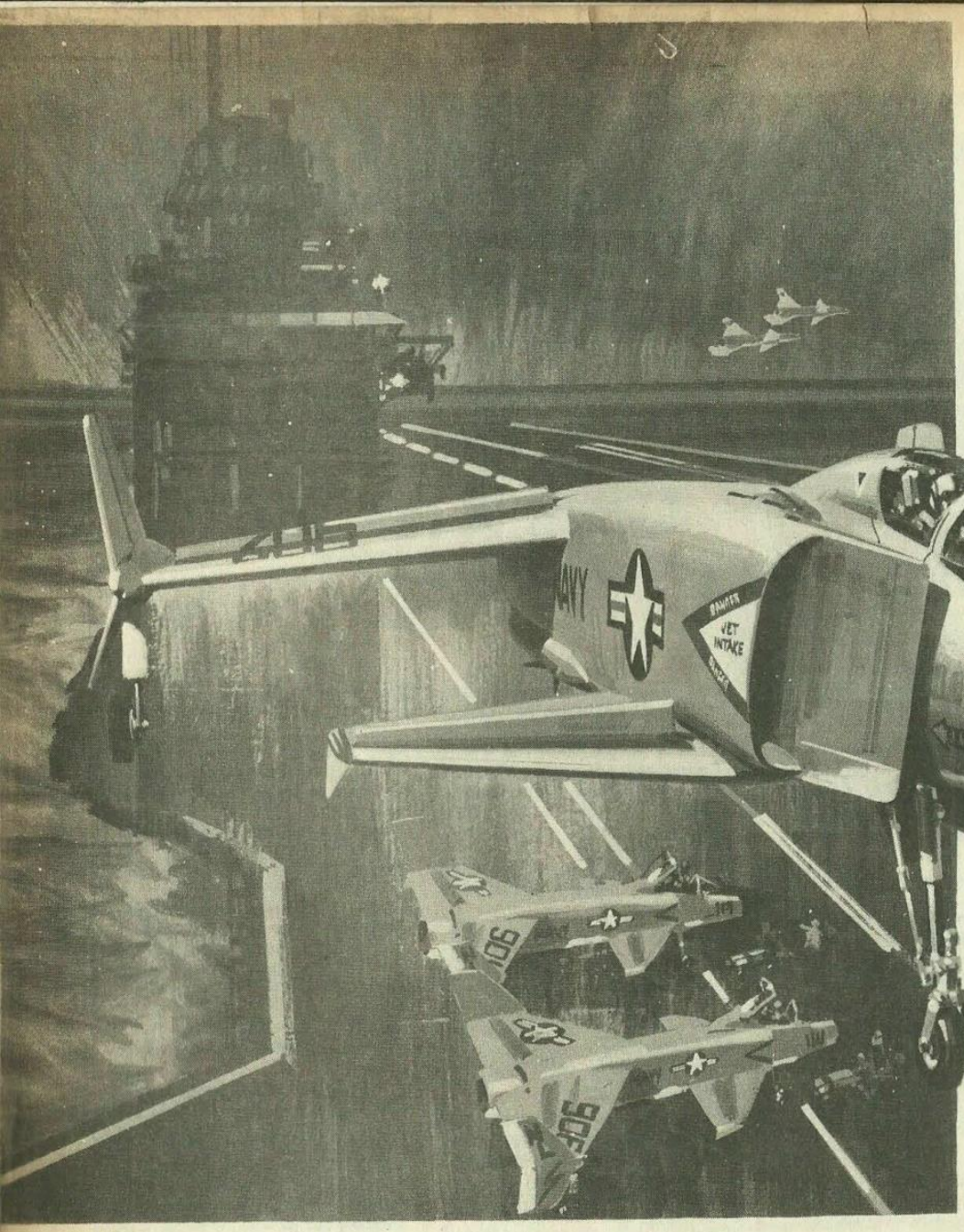
THE DEADLY DEFENDERS



FROM the deck of an aircraft carrier, a new super-fighter takes to the air. Its job is to find and destroy enemy planes.

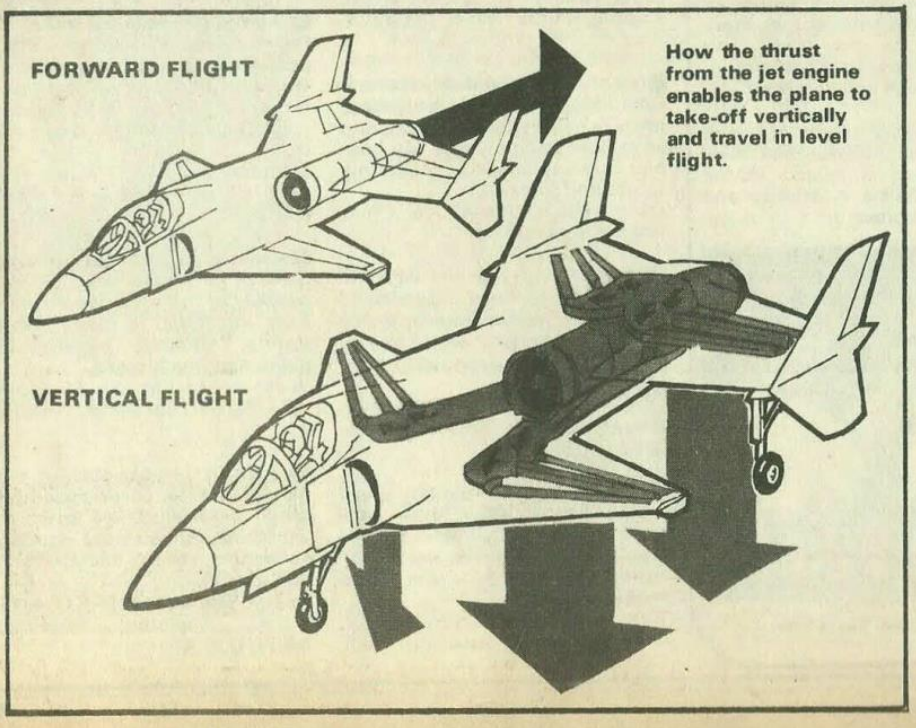
Should America become involved in another war, an aircraft carrier — known as a control ship — would sail to the danger zone with a squadron of these deadly fighters on board. When the ship's radar revealed the presence of enemy aircraft, fighter planes would soar from its decks like hornets after their prey and sting with deadly efficiency.

The plane with which it is planned to wipe the marauding squadrons out of the skies is a vertical and short take-off and landing (V/Stol) model, of which two prototypes are being built for the American Navy. It has been skilfully designed so that the lifting surfaces of its wings enable it to take off vertically, helped by the downward thrust of its powerful turbofan engine. For forward flight, the engine's power is directed through a normal jet pipe. Maximum speeds of mach 2 (twice the speed of sound) are anticipated.

With a main wing span of 30 ft, a canard (or second) wing span of about 19 ft. and a length of 42 ft., it can fly at its great speed carrying nuclear or other missiles.

Known as the XFV-12, it could be the first of a whole new family of multi-mission planes for the 1980s. One of these has already been chosen — a three-engined, supersonic vertical-take-off-and-landing fighter, which would be lifted by three engines and propelled forward by one of them.

Lift and propulsion systems of this kind may be used in a variety of other aircraft designed for many jobs, notably the support of attacks by the U.S. Marines. They should be deadly enough to deter any aggressor.



How the thrust from the jet engine enables the plane to take-off vertically and travel in level flight.

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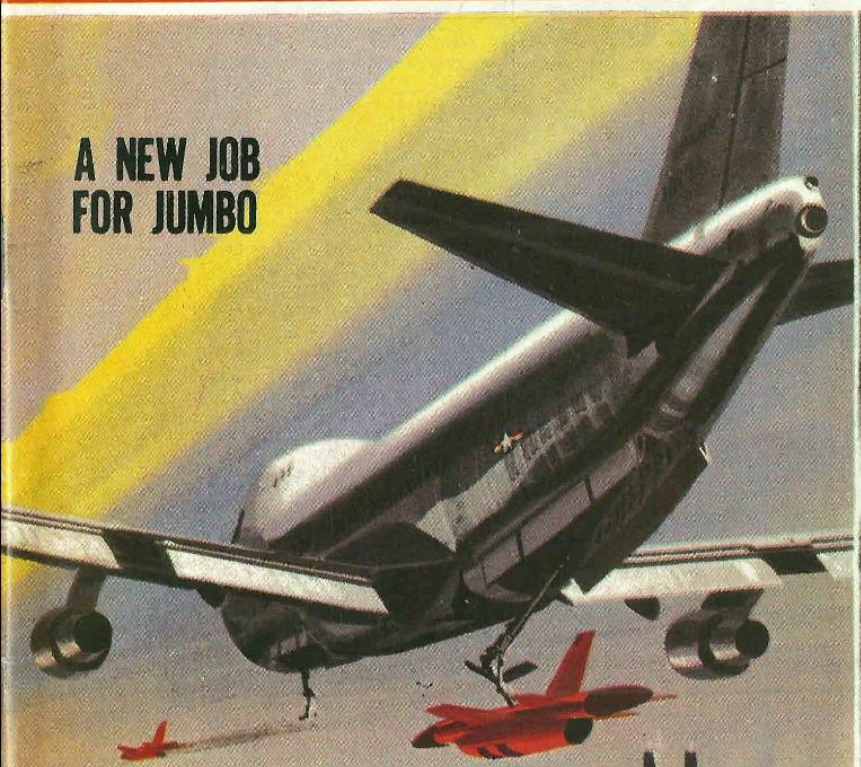
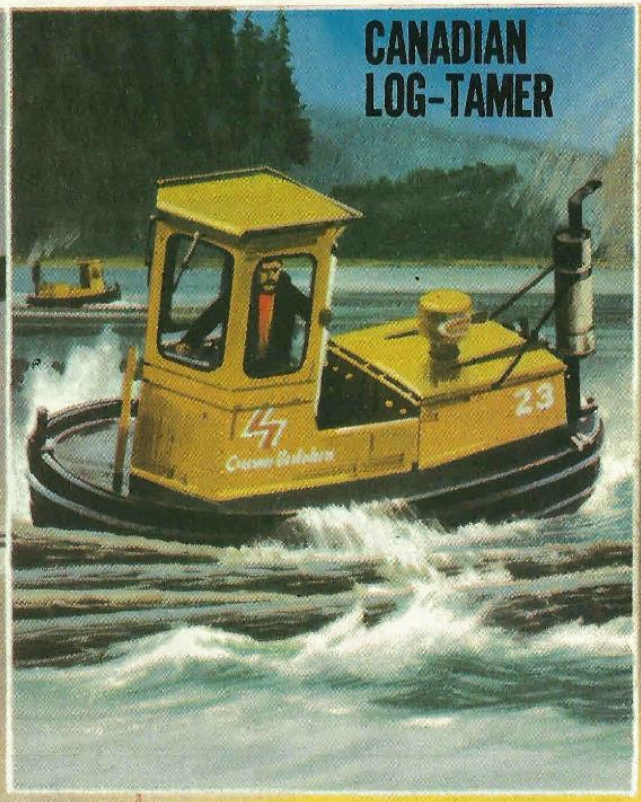
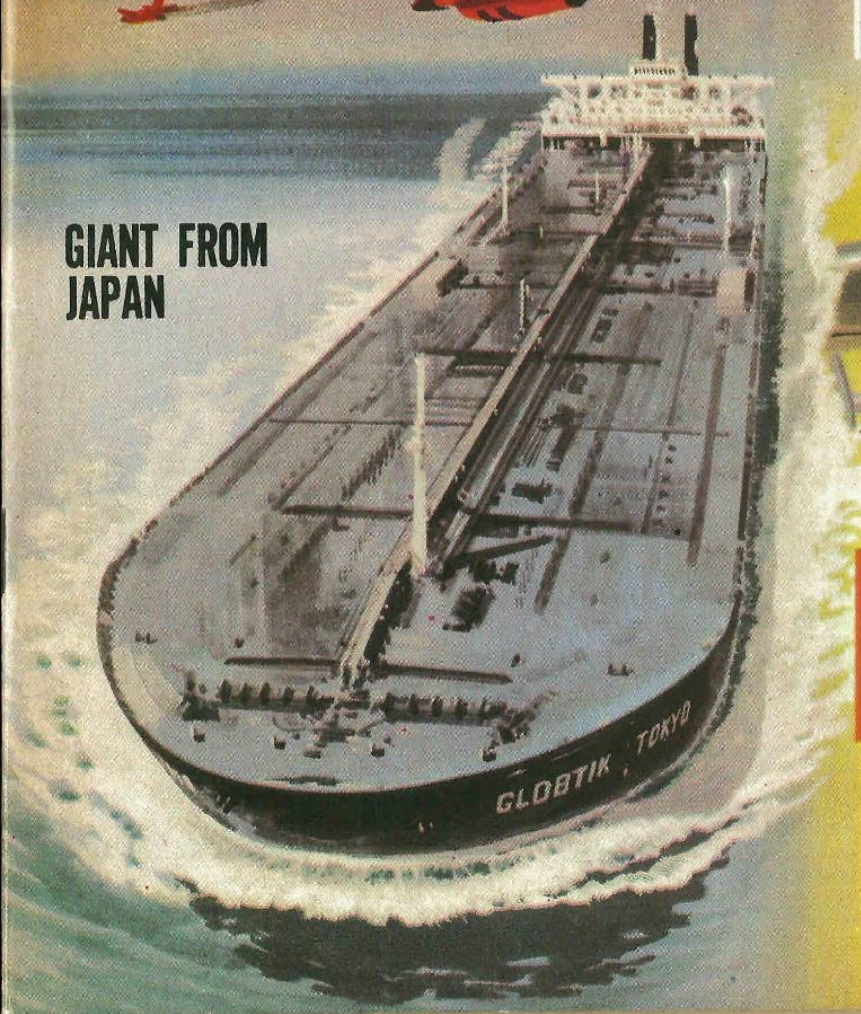


A NEW JOB FOR JUMBO



CANADIAN LOG-TAMER



GIANT FROM JAPAN

FLYING BOAT FROM THE PAST

READ ABOUT THEM INSIDE

A NEW JOB FOR JUMBO

Micro-fighters carried to and from the battle zone by a " mother " aircraft is the latest idea to be investigated by the American aircraft industry. The recent interest in remotely-piloted vehicles (RPVs) has prompted the military to ask for an investigation into the use of a Boeing 747 " Jumbo " jet as a possible carrier for micro-fighters.

The 747 could launch and recover the RPVs and re-arm and refuel them while it was in flight over the battle zone.

In one sense the idea is not new. Between the two World Wars, the United States Navy experimented with the airships *Akron* and *Macon* and developed a system of launching and recovering fighter aircraft.

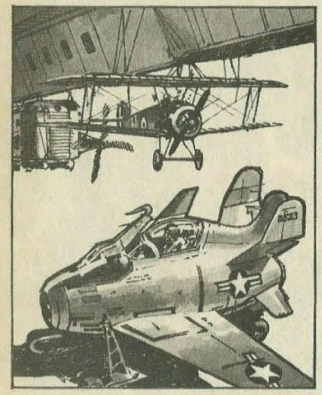
Interest in an airborne fighter carrier has been created by the increased use of RPVs for military missions. With the increasing cost and loss of overseas bases, the United States sees this idea as one solution. Instead of maintaining a large force in a foreign country, the micro-fighters could be flown to a potential trouble area.

The conversion of a 747 to these duties would involve fitting trapeze launch and recovery mechanisms fore and aft. In operation the trapeze mechanisms would allow the RPVs to be launched and recovered in mid-air on a sort of " assembly line " basis. As fast as one was launched from the forward trapeze, the next in line would move along while the others were in various stages of being refuelled and rearmed. It is estimated that six RPVs could be recovered and launched in roughly 15 minutes and the process could continue for as long as the " mother " ship carried enough armaments and fuel for the mission.

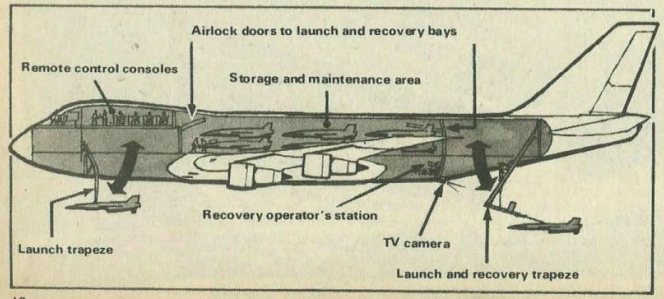
For extremely long range missions the Boeing 747 " mother " craft could return to base after launching the RPVs and another 747 could take-off and rendezvous with the flight of " micro-fighters " when they had reached the limit of their endurance.

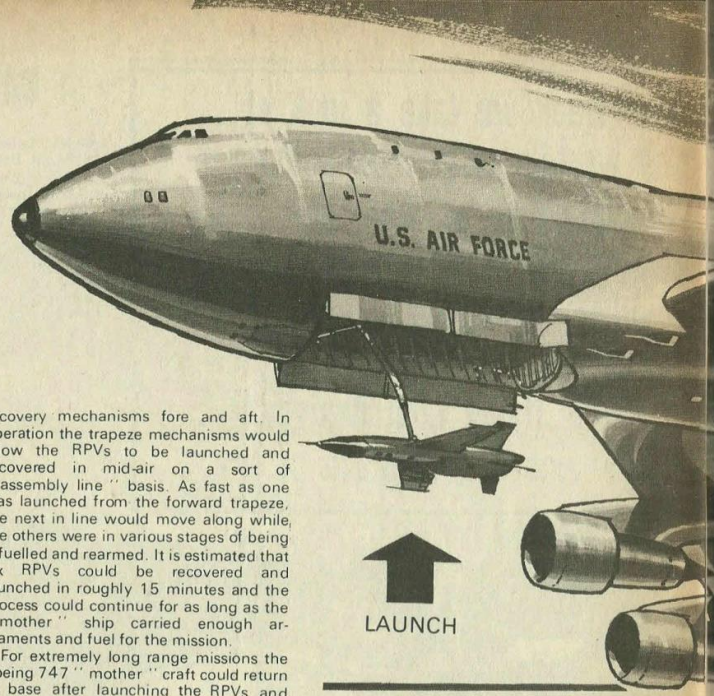
Boeing, who are carrying out an evaluation of the project, have already devised an extremely ingenious method for assisting the recovery of the RPV s. Using an ordinary television camera, coupled to a simple digital computer, the system can work out the range, position, speed and yaw and pitch angles of an airborne RPV so the aircraft can automatically be positioned for the pickup.

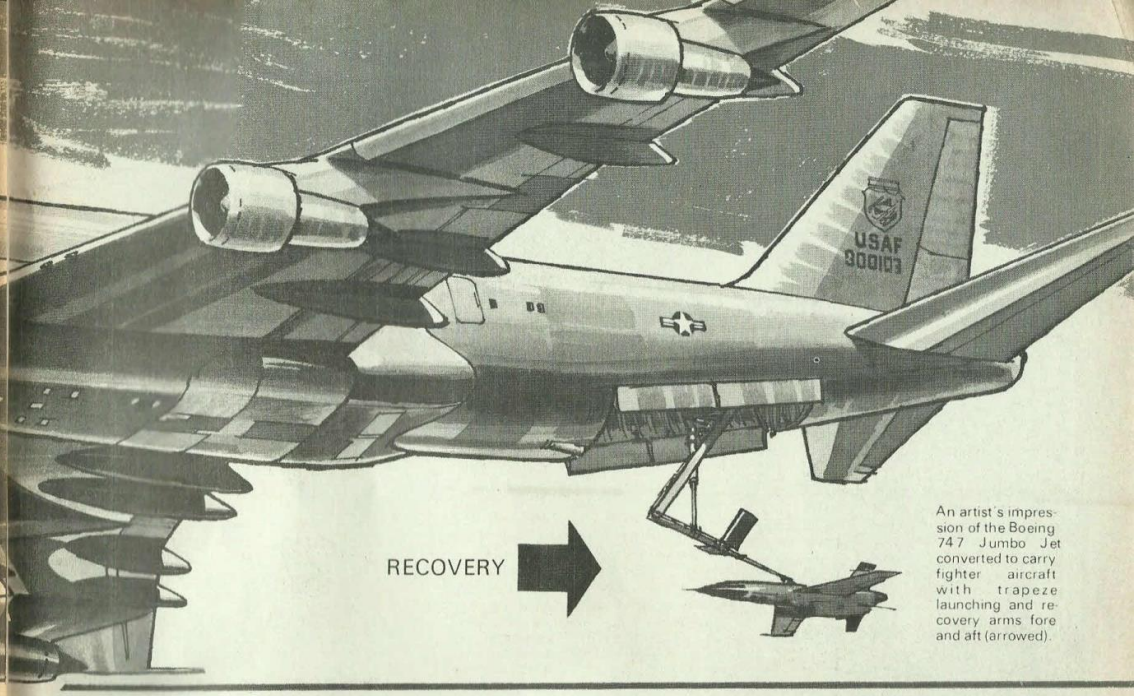
New RPV s with swept wings and designed solely for air-launch and recovery will also be built. The average 747 could carry about 20 of these and recover them in the air while flying at about Mach 0.8. The RPVs could also be programmed to make normal airfield landings and aside from a combat role, could be used to carry supplies to friendly forces inside an area defended by an enemy.



Air-launching and recovery is not a new idea. The two examples shown here are, above, a Sopwith Camel carried by airship R23 in 1918 and the McDonnell XF85 " parasite fighter " which was first flown in 1948 with a view to providing air defence during bombing in a target area. Below: Some details of the proposed Boeing 747 " flying aircraft carrier."

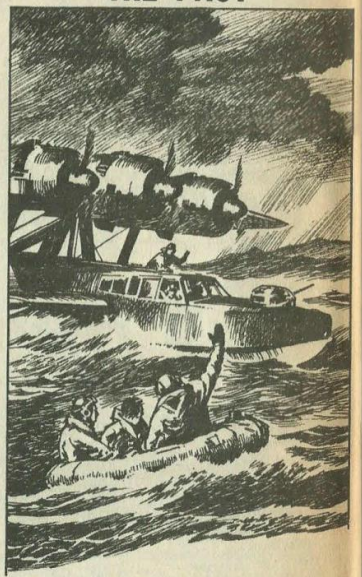




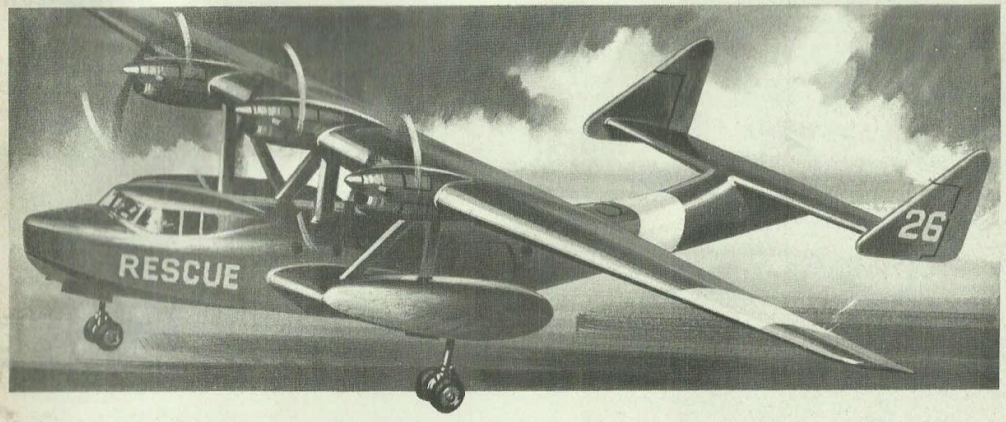


An artist's impression of the Boeing 747 Jumbo Jet converted to carry fighter aircraft with trapeze launching and recovery arms fore and aft (arrowed).

FLYING BOAT FROM THE PAST



The Dornier Do 24 design proved its ability to land on and take-off from rough, open seas in air/sea rescue operations in World War Two, and long after while in service with the Spanish Air Force.



In 1935 the German-owned company of Dornier-Werke received an order from the Dutch government for a flying boat suitable for use by the Royal Netherlands Air Force in the East Indies. The result was the Do 24, a three-engined, all-metal monoplane which first flew in July, 1937. With the outbreak of the Second World War and the German occupation of the Netherlands, the Do 24 s under construction in that country were taken over by the Luftwaffe to be used for maritime reconnaissance, air-sea rescue and transport duties.

In 1944 twelve Do 24 s were supplied to Spain for air-sea rescue duties and at least one was still in operation in 1970!

Now Dornier have announced the revival of the Do 24 design in a turboprop version which will be built in collaboration with Spain. The reason for the revival is the proven excellence of the Do 24's hull shape and general design which makes it particularly suitable for take-off and landing in rough seas. Among flying boats this performance is the exception rather than the rule, for most of them can only operate from calm, protected waters.

The new version, designated Do 24/72, retains the sponsons or " sea wings " on its hull. These give the flying boat lateral stabilisation in sea conditions of force 4 to 5. They also house fuel tanks and the landing gear for amphibious operations, and provide a useful platform for air/sea rescue duties.

The high wing, mounted on struts, reduces rolling caused by cross-winds, avoids wing dipping in rough seas and keeps the engines and propellers well clear of salt spray.

Dornier expect the Do 24/72 to be used not only for air-sea rescue work, but as a forest fire-bomber, a patrol craft, as an aerial ambulance and as a passenger craft which could carry 40 people. The first flight for the revamped amphibian will be in 1975.

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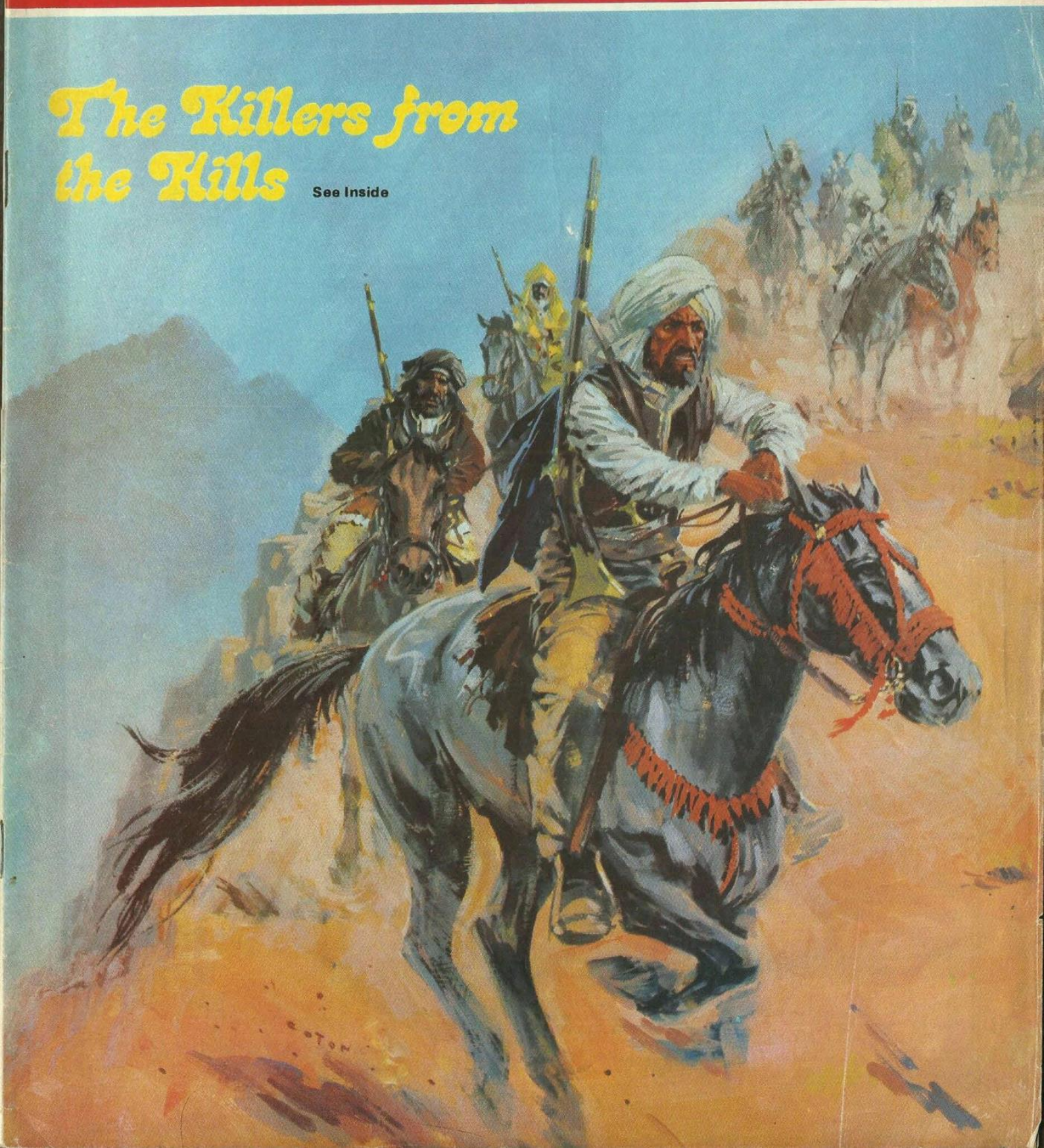
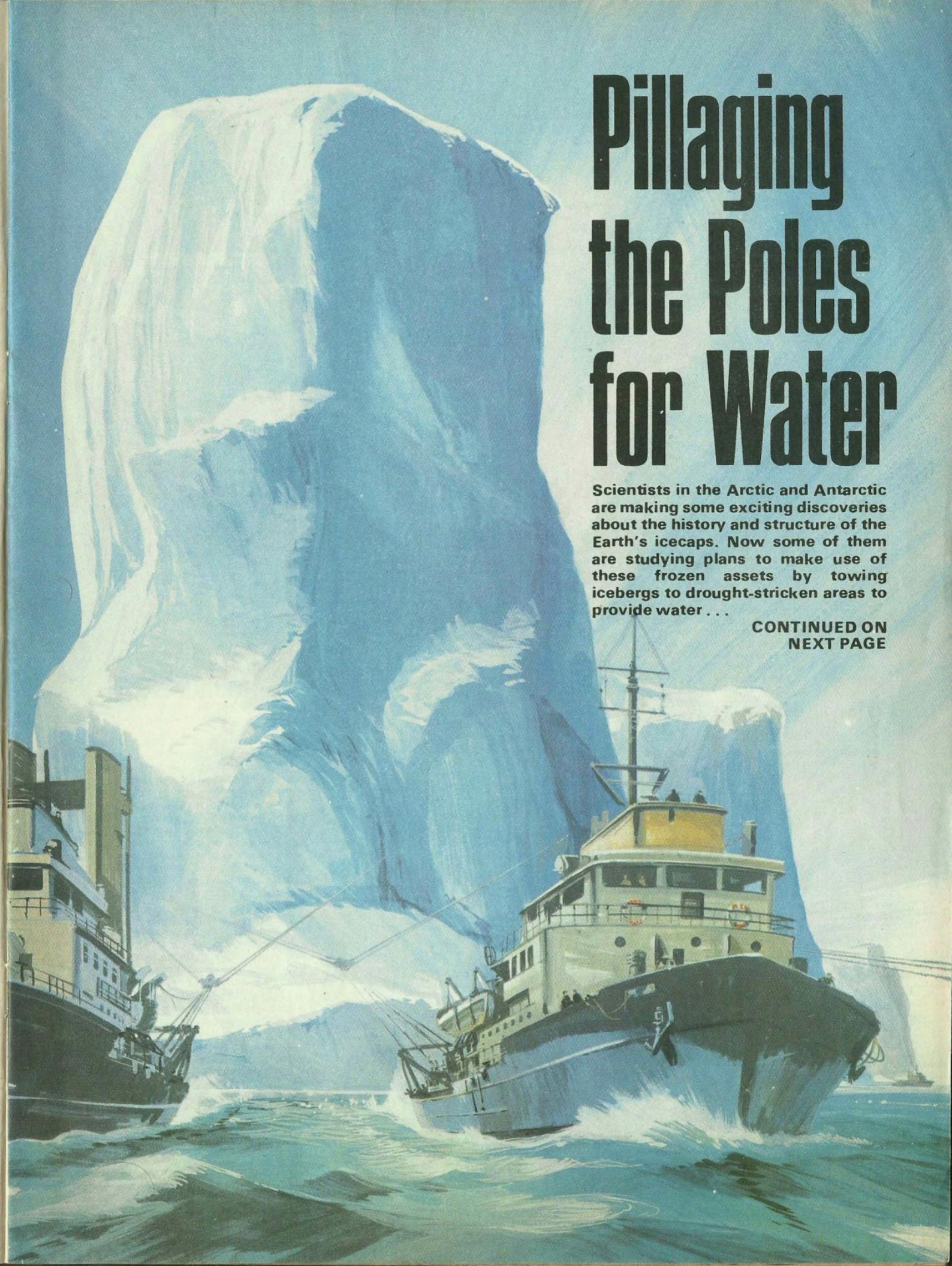
The Killers from the Hills

See Inside





Pillaging the Poles for Water

Scientists in the Arctic and Antarctic are making some exciting discoveries about the history and structure of the Earth's icecaps. Now some of them are studying plans to make use of these frozen assets by towing icebergs to drought-stricken areas to provide water . . .

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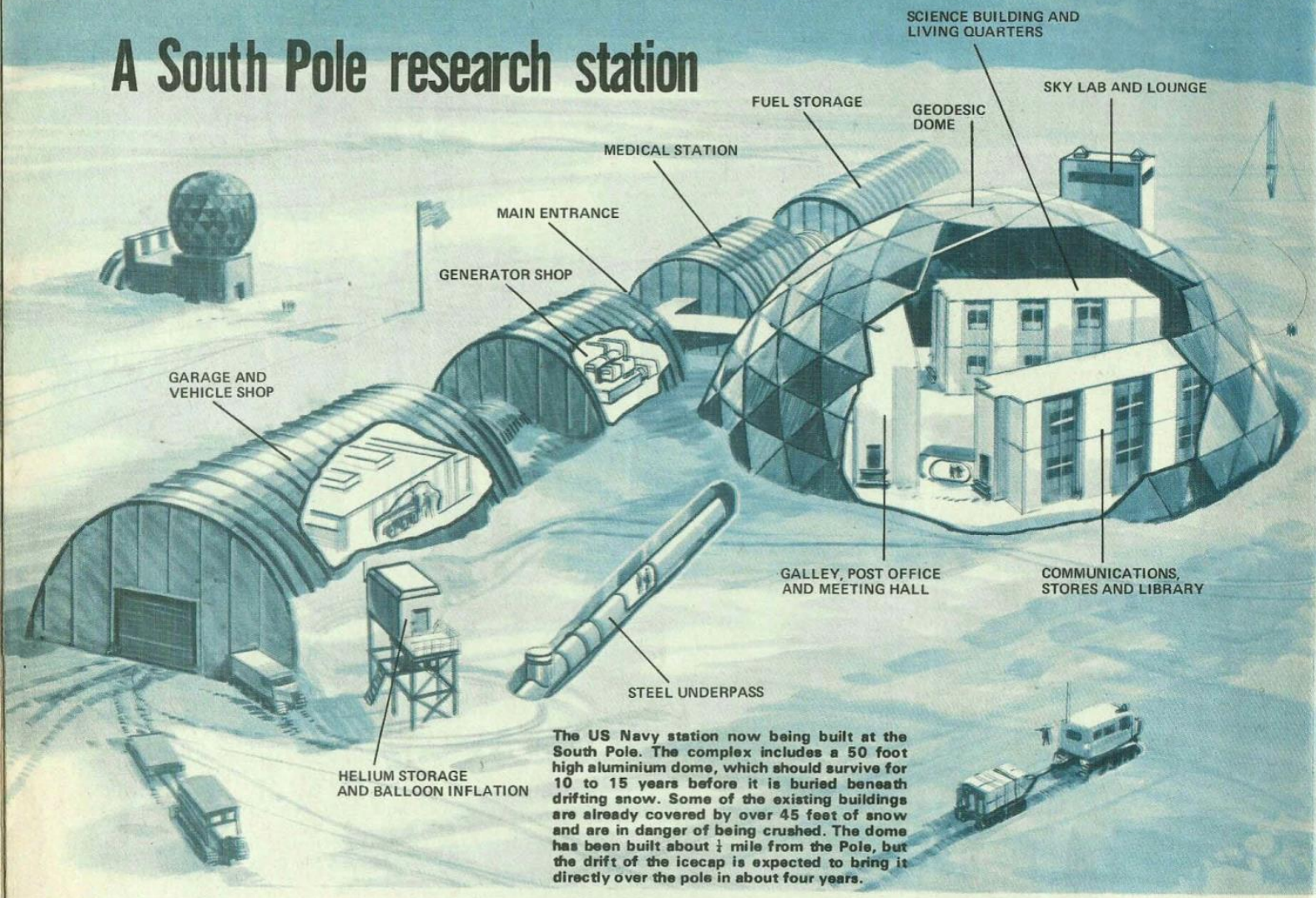
A South Pole research station



The US Navy station now being built at the South Pole. The complex includes a 50 foot high aluminium dome, which should survive for 10 to 15 years before it is buried beneath drifting snow. Some of the existing buildings are already covered by over 45 feet of snow and are in danger of being crushed. The dome has been built about ½ mile from the Pole, but the drift of the icecap is expected to bring it directly over the pole in about four years.

Research station staff arrive in a Sno-cat to greet a British ice-breaker bringing supplies to the Antarctic Icecap.

COME to sunny California for winter sports on icebergs . . . try ski-ing, tobogganing, skating above blue Pacific waters . . . enjoy mountain thrills on the 35th Parallel off Los Angeles. . . ."

A Hollywood director's dream for a spectacular film? A tourist's fantasy? A scientist's incredible scheme for changing the seasons? No. The tempting picture of skiers whizzing down icy slopes with a sun-dappled ocean for a background is a real possibility. And it comes straight out of research laboratories where scientists are trying to unlock the secrets of the Polar wastes.

Weather forecasting, the history of the Arctic and Antarctic, the search for gas and oil beneath the frozen continents around the North and South Poles and tracking orbiting satellites are all part of the normal, day-to-day work of scientists from more than 20 nations working at the top and bottom of the world. Sometimes they produce ideas born in fantasy. Often the fantasy becomes reality as the 20th century has testified.

Sixteen years ago, a scientist at the Scripps Institute of Oceanography at La Jolla, California, proposed a scheme to float a 20 mile long chain of icebergs from the Antarctic to the southern Californian coast to provide fresh water to a dry, over-populated region.

The idea was pooh-poohed as a piece of nonsense. But today the proposal is being studied again not just by the Scripps Institute but also by the US National Science Foundation and the Rand Corporation.

Scientists believe that icebergs could provide the cheapest answer to solving southern California's water problem. While the scheme

is still very much in its infancy as a practical proposition, it is still considered feasible.

According to the experts, one two-mile long iceberg would yield about one million acre feet of soft water — purer even than spa springs — and more than the 720,000 population of San Diego use in a year. It is estimated that fresh water from the icebergs could be delivered to southern California for about £10 an acre, one foot deep — half the cost of Colorado river water brought to the area via the California viaduct. The water is fresh because the icebergs break off the Antarctic ice cap, which has been produced by snow and ice over thousands of years.

Apart from providing an abundance of fresh water, scientists consider that the icebergs would be able to give Californians a permanent access to winter sports. Adapting them for skiing and skating, or even installing chair lifts, would be a comparatively simple operation. A ferry boat service could take winter sports lovers out to the icebergs, which, it is proposed, would be run aground about a mile offshore. A possible site lies off the US Marine Corps camp Pendleton, a few miles south of President Nixon's Western White House at San Clemente.

Scientists visualise making up a chain of eight icebergs, each about two miles long, one mile wide and 900 feet thick. The first would serve as the "locomotive" equipped with electrically driven propellers and drawing power from a slack cable linked to an escort ship. They would travel north across the Pacific at about one knot.

A slow journey, indeed, from the five million square mile continent, which has attracted crowds of explorers and scientists since the last war.

POLAR TOWNS

The main American base is at the headquarters of the US Navy Antarctic Support Activities at McMurdo Sound where midsummer temperatures hover around freezing point and winter ones drop to −90 degrees Fahrenheit.

About 150 huts, houses, laboratories, a church, a hospital, a weather station, a satellite tracking observatory and stores for food and equipment have created a township on ice. Another American base is at the South Pole where there is little to see apart from a network of radio masts. About 2,000 men live there in inter-connected huts and tunnels, studying among other things tremors from earthquakes all around the world. A new station, costing £1 million, is now being built there.

And at the top of the world more than 100 scientists are involved in trying to build a mathematical model of the entire Arctic ocean. The largest scientific camp ever built on the Arctic icecap is being set up more than 280 miles north east of Point Barrow, Alaska, the most northerly point of land in the US. Known by the code name AIDJEX-72, an acronym for Arctic Ice Dynamic Joint Experiment, the expedition will study the system of the Arctic ocean, especially the inter-action of the water with the under-surface of the ice and the ice surface with the air.

There will also be two satellite camps, each to be established 100 miles from the main camp to form a triangle for special measurements. With a mathematical model of the ice cap, statistical experiments will be carried out with a computer.

Britain also has a direct interest in the Arctic. The Meteorological Office has asked Russia to help with weather forecasting by providing information about ice formations over 50 years in the Barents Sea.

For the cause of Britain's present sequence of mild winters is believed to be due to an unusual recession of ice, which has moved away to the north from Iceland by as much as 100 miles, allowing warmer south westerly air streams to continue to flow across the Atlantic.

The quest for the secrets that lie beneath the frozen land became an international concern, resulting in the leading nations — Australia, Argentine, Belgium, Chile, France, Japan, New Zealand, Norway, S. Africa, Britain, the US and Russia — signing the Antarctic Treaty on December 1st, 1959. It reserved the area south of 60 degrees South latitude for peaceful research and provided for international co-operation in scientific investigation. Nuclear explosions and dispersal of radioactive waste were banned. The treaty was acceded to subsequently by another 10 nations not actively engaged in the area.

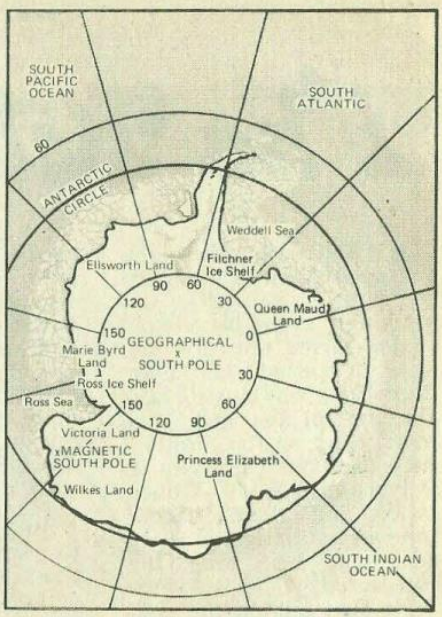
The British research station is based at Halley Bay on the edge of the Weddell Sea about 900 miles from the South Pole. It has just been rebuilt for the fourth time because over the years layers of snow have covered and crushed the original huts. The first ones to be built now lie 70 feet below the surface. The latest buildings are being constructed inside a steel tube 20 feet in diameter, which, it is hoped, will extend the life of the station for several years.

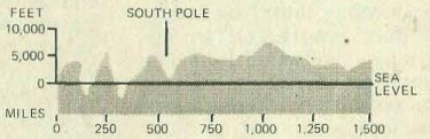
Russia also has hundreds of scientists and specialists conducting widespread exploration from their base in MacRobertson Land. A major scientific survey launched last year has uncovered new data about geological formations.

The Russians are also co-operating on a big scale with the Americans, having agreed to contribute £400,000 a year towards the United States Deep Sea Drilling Project and to take part in it under a Soviet-American agreement on co-operation in science and technology signed last May.

The project is directed by a consortium of five institutions in the US under the administration of the Scripps Institute. The Soviet financial outlay will represent about a tenth of the cost of the programme being carried out by the project's drill ship, *Glomar Challenger*. She has driven nearly 300 holes in the sea bed in various parts of the world and obtained information of unique scientific and commercial value.

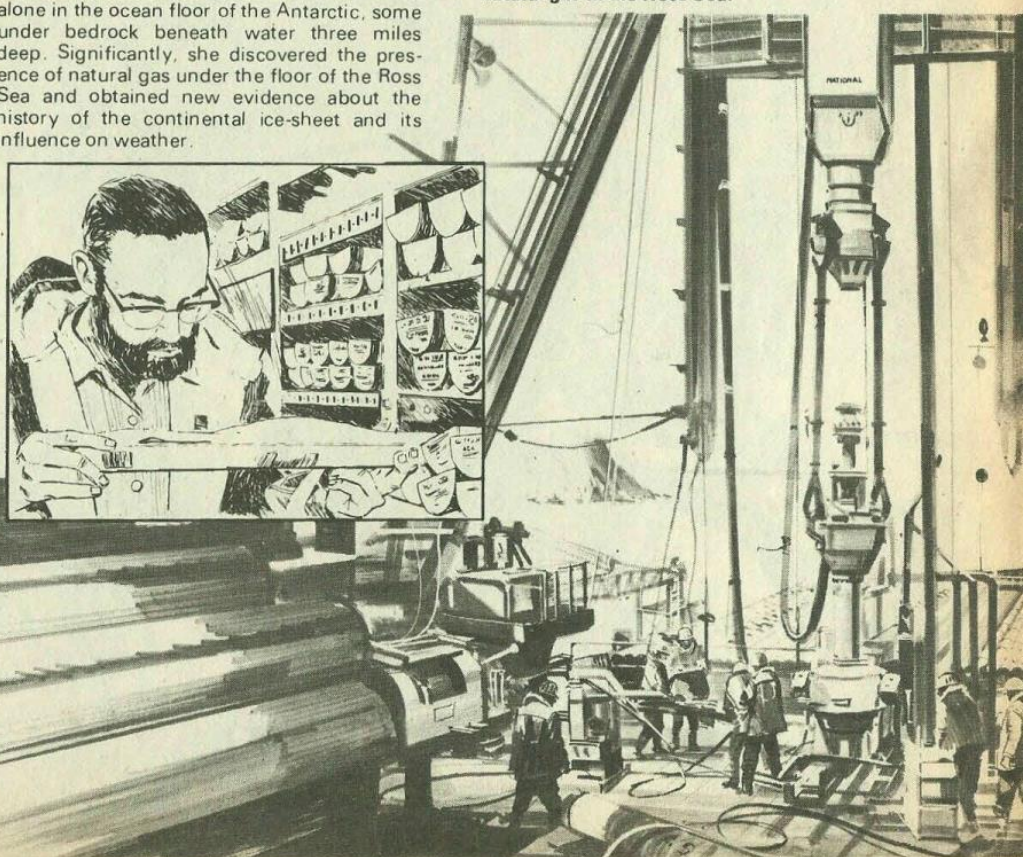
The *Glomar Challenger* drilled 16 holes alone in the ocean floor of the Antarctic, some under bedrock beneath water three miles deep. Significantly, she discovered the presence of natural gas under the floor of the Ross Sea and obtained new evidence about the history of the continental ice-sheet and its influence on weather.





A map of the South Pole and a cross section of the icecap showing the land mass (dark grey) and the thickness of the ice and snow covering (light grey).

Left: A refrigerated "library of ocean cores," samples of mud and sediment taken by boring into the sea bed. Below: Aboard the drilling ship *Glomar Challenger*, looking forward over a stack of drill pipes leading to the drilling derrick. The vessel has been used to drill into the Antarctic ocean floor beneath water three miles deep and has discovered the presence of natural gas in the Ross Sea.



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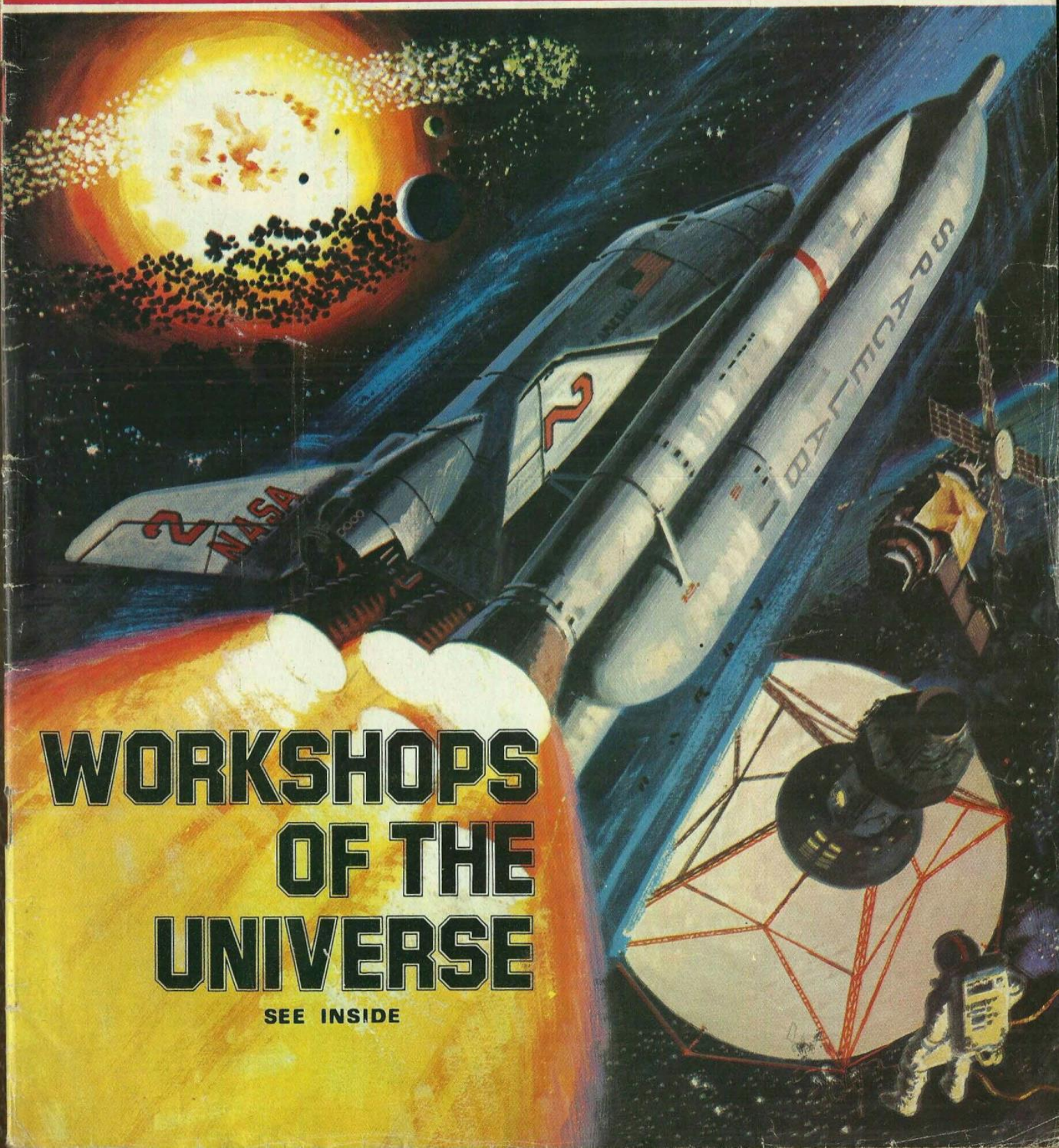

WORKSHOPS OF THE UNIVERSE

SEE INSIDE

WORKSHOPS OF THE UNIVERSE

Top: Neil Armstrong, the first astronaut to set foot on the Moon. Above: The explosion aboard Apollo 13 on the outward journey to the Moon which made world headlines and, ironically, renewed public interest in the Space Race.

IN the Space Race, nothing succeeds like failure. Ever since Man first realised that the lights in the sky were worlds, he has dreamed of reaching the Moon. Yet Neil Armstrong had scarcely planted one televised boot upon the lunar surface, when a large portion of the human race decided that it was bored to death, and switched over to Star Trek or Coronation Street. It took the near-disaster of Apollo 13, with astronauts Lovell, Haise and Swigert nursing their damaged spacecraft back to Earth, to put the Space Race back in the headlines.

When the spectacular series of moon-shots ended, NASA faced the boredom problem again. If viewers were losing interest in lunar landings, why should they be excited at the prospect of orbital space stations? Many people are not only bored, they are actually hostile towards NASA. They believe that the money and scientific talent spent upon the space programme should be devoted to solving problems here on Earth, instead. Their intentions are good, but they ignore the fact that one small planet will not last for ever. In time, Earth will be used up. We cannot afford to wait until then before we explore the resources of the Universe. We must do it now.

The aluminium micrometeorite shield that tore free from the side of Skylab One, jamming the solar-power panels, seemed to have doomed the space laboratory. To the opponents of NASA, it was exactly the sort of incident they needed to prove their case. Because of the ingenuity of the Huntsville and Johnson spacecraft centre engineers, and the courage of Charles Conrad and his crew, it has become exactly the opposite. Like Apollo 13, Skylab has shown that men can deal with emergencies beyond the atmosphere. Newspapers, radio and television have

After the Moon landings and Neil Armstrong's 'great step for Mankind', where does the next step lead? The first in a three-part series about space exploration and exploitation

brought the drama of the struggle to the world below. Once again, failure has been more successful than success!

Expensive as Skylab is, it is only the first step towards a permanent space base. After it will come the Space Shuttle. Locked to the side of a towering 180-foot fuel tank filled with liquid hydrogen and oxygen, the shuttle will rocket up into orbit from Cape Kennedy. Once in orbit, the burned-out fuel tank will be jettisoned along with the spent solid-fuel booster rockets. With its thick cylindrical fuselage and stubby delta wings, the shuttle will swing around Earth rather like an airliner that has gone astray. When its mission has been completed the rocket motors will fire again, nudging it out of orbit and back into the atmosphere. Using rocket fuel carried in small internal tanks, the shuttle will slide into a precisely-calculated glide path which will end in a conventional wheels-down landing on a runway.

This ability to take-off as a rocket and return as an aircraft changes the whole nature of the space programme. No longer will it be necessary to discard a gigantic Saturn rocket after every launching. The shuttle, as its name implies, will shuttle between Earth and space on scores of trips. With a cargo-bay that can hold almost 30 tons of payload, it can lift into orbit anything from a communications satellite to replacement

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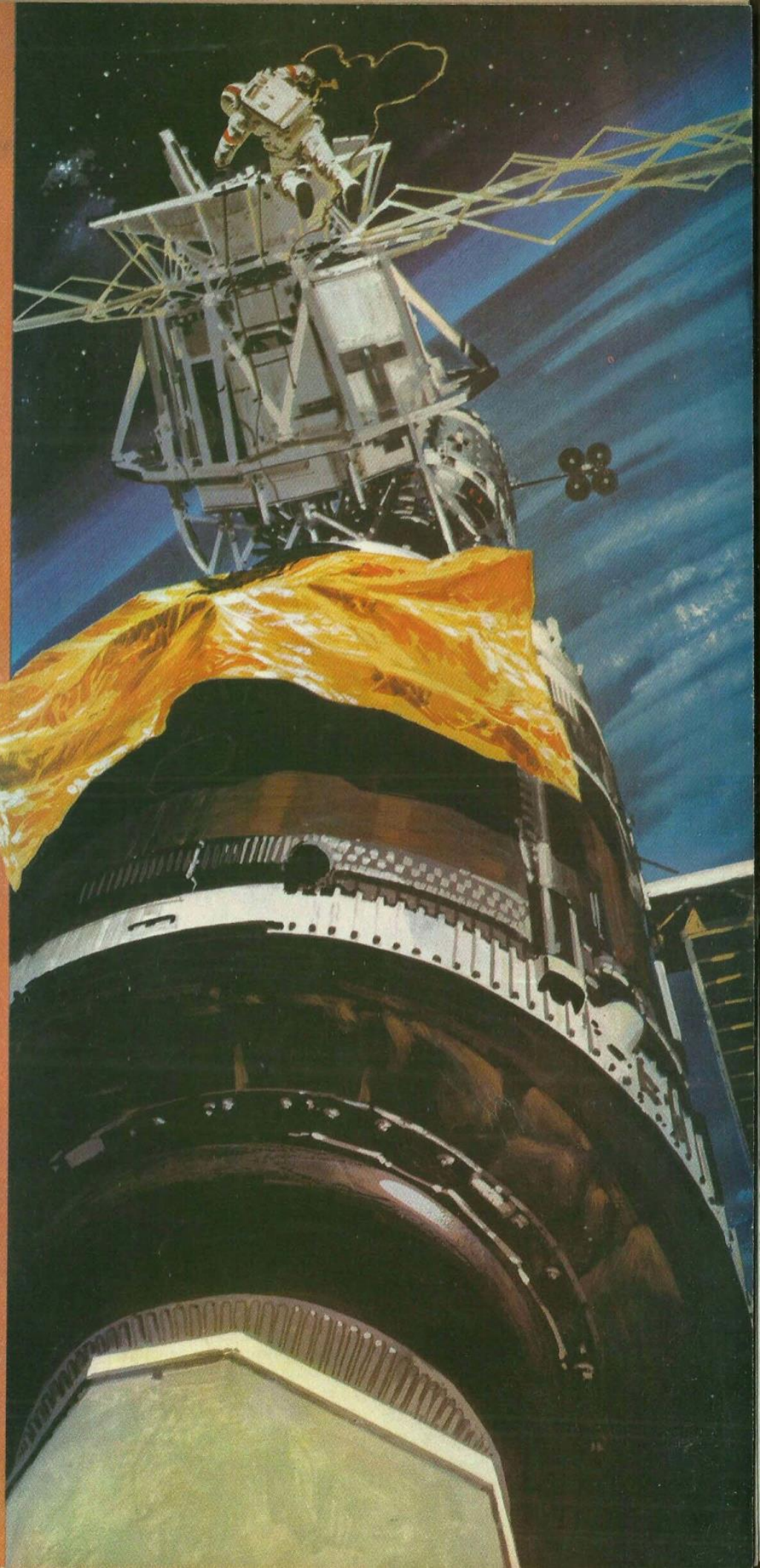


Right: Another space disaster, this time the failure of the solar panels on the Skylab mission, once more brought the Space Race into the public eye. The "Solar Parasol," designed in six days, was carried into space and erected like a spring-loaded umbrella to shade the spacecraft from the Sun and reduce its inside temperature. This running repair was dramatic proof of Man's ability to carry out complicated and dangerous work in space.

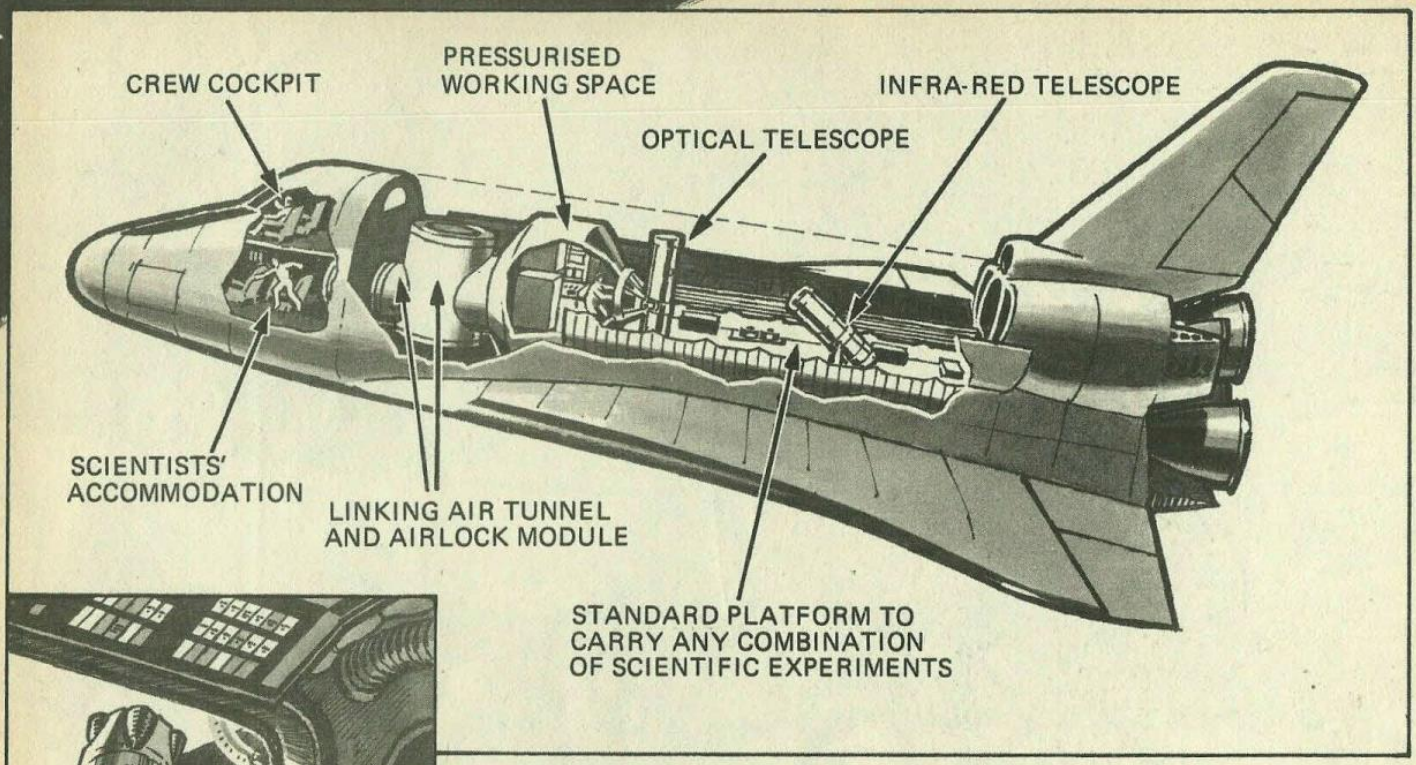
crews for the larger, more complex Skylabs of the future. After 1980, by which date the shuttle should be in service, the Universe will cease to be reserved exclusively for astronauts. The scientists who journey into space to conduct experiments will be merely passengers. Like the air travellers of today, they will leave the flying to trained pilots and navigators.

WORKING TRIPS

For Europeans, the most important mission flown by the shuttle will concern Spacelab, the first orbital laboratory to be built in Europe. After many unsuccessful attempts to design a rocket capable of putting satellites into orbit, the European Space Research Organisation (ESRO) agreed to co-operate with NASA on the Spacelab project. By August 1973 the final design must be agreed upon so that construction can begin. When it floats out from the 60ft by 15ft cargo-bay of the shuttle, high above the Earth, Spacelab will be able to accommodate scientists in reasonable comfort for as long as four weeks. Whether men and women can live and work in weightless conditions for longer than this without damaging their health, is not yet known. Tests carried out upon Conrad, Weitz and Kerwin after their return from the first Skylab mission may provide the answer.

Russian scientists, too, will be waiting with interest for the report on Skylab.

The Space Shuttle soaring into orbit, at the moment of shedding its two solid-fuel booster rockets. Its own rocket engines will suck in fuel (liquid hydrogen/oxygen) from the massive tank on which it perches. Before the Shuttle achieves orbit the tank is jettisoned and parachuted into the sea for recovery and re-use.



Above: The Space Shuttle shown carrying out one of three planned mission loads for the European "Spacelab" project. The standard mounting platform for the experiments is carrying two telescopes, one for standard astronomical photography and one for infra-red studies. The scientist "passengers" operate the telescopes from a pressurised cabin linked to their accommodation by a tunnel fitted with an airlock module. This allows docking with a free-orbiting satellite or another orbiting space vehicle, and also permits them to go "space-walking."
Inset: The "Space Tug" will be a remotely controlled booster rocket carried into orbit by the shuttle which can then use it to move equipment in space.

Three years ago, cosmonauts Dobrovolsky, Patsayev and Volkov died during their return to Earth from the orbital station Salyut One. Their twenty-three day spell in orbit was a record, until the current American missions surpassed it. Since then, Russia has had considerable trouble with the new station, Salyut Two. Had all gone well with it teams of Soviet and American spacemen might have circled the world simultaneously. Now that both nations have admitted the wastefulness of conducting completely separate space programmes, plans are well advanced for combined missions using the resources of Skylab and Salyut.

UNITED IN SPACE

In May 1973, Russia announced that Alexei Leonov and Valeri Kubasov would become the first cosmonauts to link their spacecraft with its American counterpart. Changes in the design of both craft should make it possible for crew members to pass from one to the other through a connecting lock. As more and more orbital stations and vehicles go up, and the number of people in space increases, so does the possibility of accidents. In an emergency, it could be vitally important that rescuers board the distressed craft as swiftly as possible. To do this, matching exit and entry systems are essential. The first demonstration of this ability to link up is planned for 1975.

While the cosmonauts prepare for this future event, Soviet designers are pushing ahead with the 303-Project. This is a Russian space shuttle which, like the American version, will be able to dock with orbital stations or with other space vehicles. After the shuttles will come the space tugs, basically unattached rocket motors operated by remote control, which can be used to pull or push pieces of equipment into place during the building of larger space stations.

Among the more ambitious designs for these larger systems is a huge wheel shaped structure capable of holding more than 100 people. It may be necessary to have some form of artificial gravity within these stations, in order to protect the health of the occupants or to enable them to carry out certain experiments. If this is so, the only method so far known is to spin the station on its axis. The centrifugal force created by the spin will impose a sensation of weight upon the station crew. It is not a completely satisfactory substitute for gravity, for the strength of the force decreases as one moves inwards from the rim of the wheel to the centre. At the centre there is complete weightlessness. Until some new Einstein discovers a means of generating gravity, however, centrifugal force will have to serve.

NEW INDUSTRIAL AGE

When Russia, America and Europe have put these costly and complicated mechanisms into orbit, what will they do? So far, most published reports on the space programme have dealt with our discoveries about the origin of the Moon and the Solar System, or have emphasised the benefits to Earthly medicine and industry arising from research into the problems of spaceflight. Now we are moving beyond this, into a new Industrial Age. Skylab and Salyut are, on a small scale, the first orbital factories, the first attempt to exploit the vast goldmine in the sky that is the Universe. In the second part of this article we shall look at some of the riches which may be found there.

NEXT WEEK:
POWERHOUSE IN THE SKY
Tapping the energy of the Sun.

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WHAT HAPPENED TO 'LADY LINDY'?

SEE INSIDE

What Next In Space?

POWERHOUSE IN THE SKY

Space provides conditions which can only be obtained at great expense on Earth For example, there are billions of cubic miles of perfect vacuum and it might even be profitable to " export this nothing " in containers to Earth for scientific and industrial use

The Solar System is a machine and the Sun is its engine. When we establish factories in space, we will merely be repeating, in a minor way, what Nature has been doing since the Universe began.

The vacuum through which the planets whirl is thinner than any ever produced by Earthly laboratories, yet it seethes with energy. Mercury, Venus and Earth revolve within the outer atmosphere of the Sun, continually bombarded by storms of sub-atomic particles. Neutrinos, rushing outwards into deep space, slide through Earth's 8,000-mile thickness of rock and metal like rifle-shots through jelly. Cosmic rays, sweeping across the galaxy,

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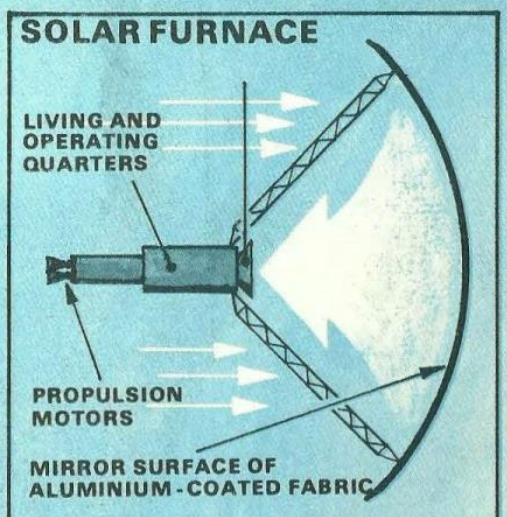
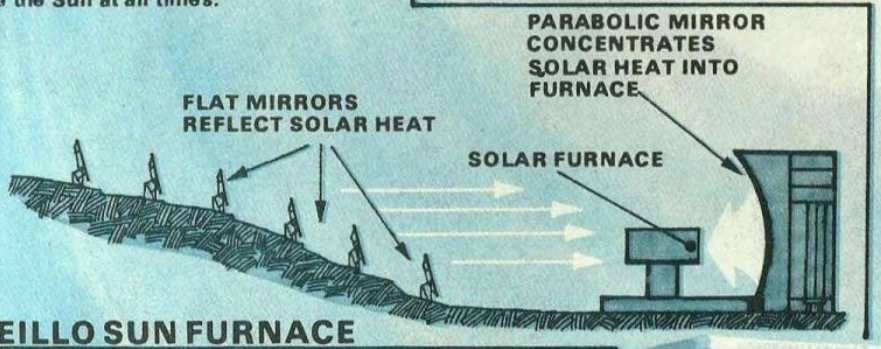


The Odeillo Sun Furnace, high in the French Pyrenees (below) uses movable secondary mirrors to follow the Sun and reflect its heat on to the main parabolic mirror. The Solar Furnace in space, shown above and in the artist's impression (right) would need only a big parabolic mirror which would be turned to face the Sun at all times.

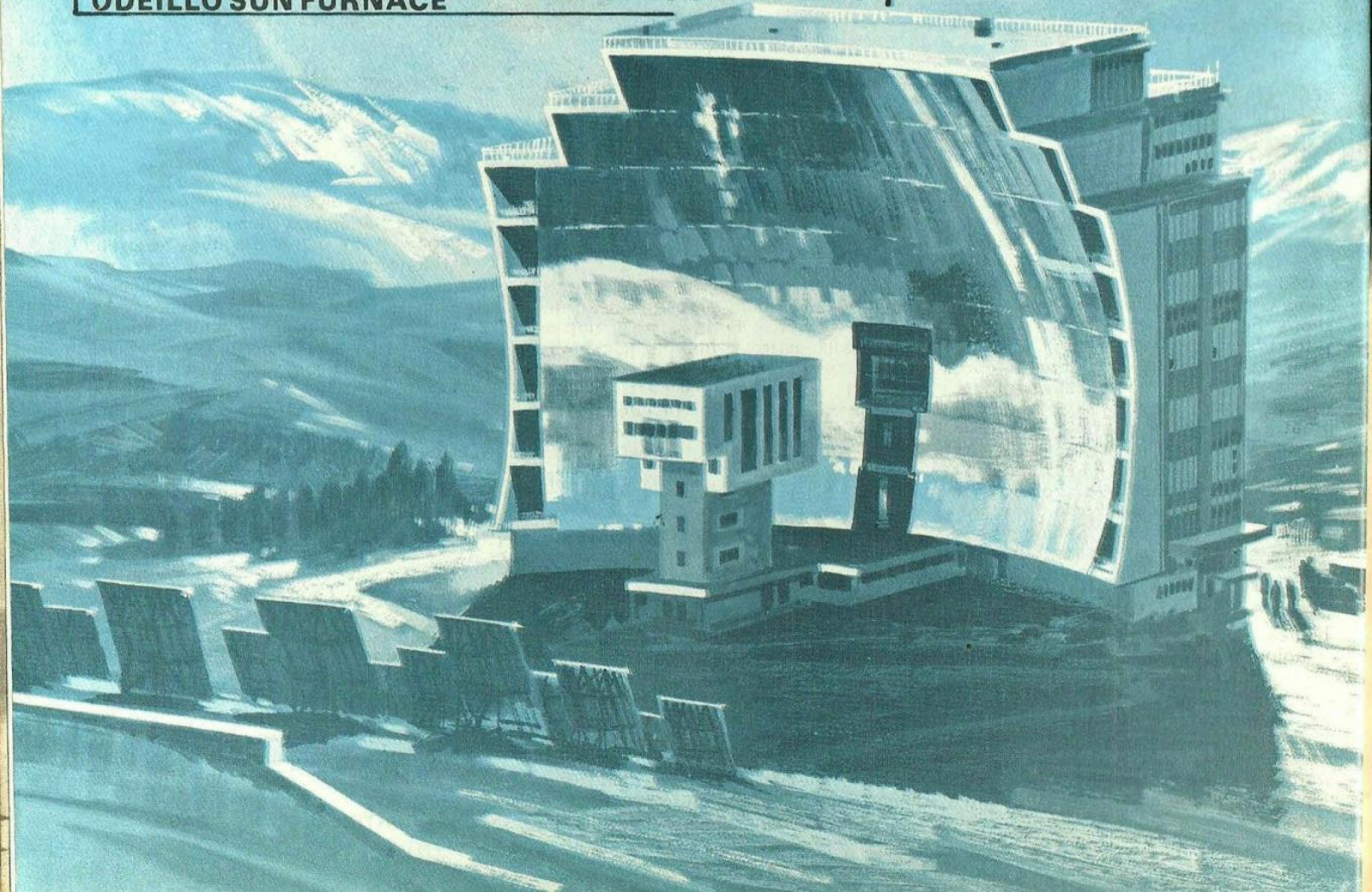


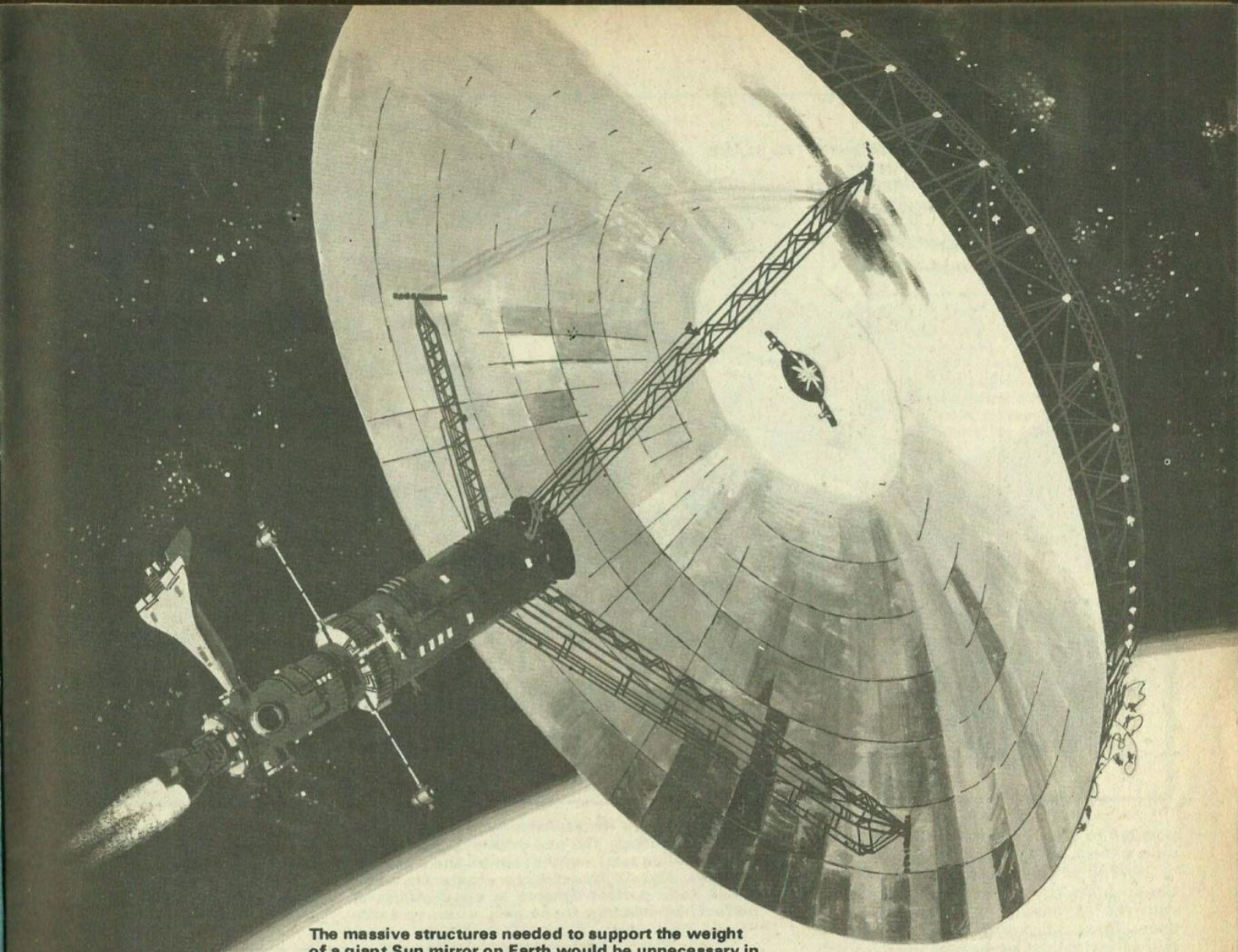
plough into the upper air of our world and destroy themselves in violent atomic collisions. Under our shield of atmosphere, we squander our shrinking supplies of chemical fuels and talk with alarm about an energy crisis, while on every side of us incredibly powerful forces rage.

To know that we are surrounded by energy sources is encouraging. To tap those sources and use them is another matter. Compact nuclear power plants are the most likely installations to be found in the first space factories. Like fire, nuclear power is a useful servant, but a dangerous one. Already the world's atomic plants are having difficulty in safely disposing of radioactive waste materials. Usually, it is considered sufficient to seal them in insulated containers and bury, or submerge them until the radioactivity has fallen to a safe level. Since Earth's population could easily have increased to several thousand times its present size long before this level has been reached by waste already buried, the notion that it will remain safely distant from human contact is more than optimistic. It is idiotic. We must not carry that kind of thinking into space.

On the slopes of the French Pyrenees stands one answer to the power question. Row upon row of giant mirrors catch the sun's light and hurl it against the curved face of the greater mirror before them, in which their own images are reflected. From this glittering surface the combined beams leap back in a blinding shaft, spearing into the heart of a solar furnace. At almost 4,000 degrees Centigrade, it is the most intense concentration of solar heat ever achieved by Man. And it is clean, uncontaminated power. For almost one-third of the year, clouds prevent the French Solar Energy Research Laboratory from reaching its full capacity. In space, such a system could operate perpetually in the full, unfiltered glare of the sun. Beyond the pull of gravity, mirrors as large as playing-fields could feed power to orbiting workshops, unhampered by problems of weight or fragility.

Obviously, no government is going to put factories into space to do things which can equally well be done on Earth. Nor will private industry be inter-





The massive structures needed to support the weight of a giant Sun mirror on Earth would be unnecessary in space and the size and power of such furnaces would be virtually unlimited.

ested in spending money on such ventures without the possibility of making a profit. So what is it about space which attracts both of them?

First, that the Universe provides conditions, freely and in limitless quantities, which can only be obtained on Earth at great expense. For example, there are countless billions of cubic miles of vacuum, so perfect that it has been suggested that it would be profitable to send it in containers to Earth, for scientific and industrial use. Selling tinned emptiness may sound absurd, but this is because our ways of thinking are still planet-bound.

Second, that there must be possibilities in space that we cannot even imagine yet. In past ages, explorers in new lands usually sought the type of treasure with which they were familiar. Voyagers to the Americas looked for fabulous cities of gold, but discovered instead the potato and tobacco. Now huge industries are founded upon these plants, while the cities of gold remain a dream.

Most difficult of all space conditions to understand, or to simulate on Earth, is weightlessness. By flying an aircraft on a parabolic path — that is, climbing at high speed and then curving over and down — weightlessness can be achieved at the top of the curve for several seconds. Brief though this period is, it has produced some surprising results.

'SLEEPING' FLAME

A candle flame seems a simple phenomenon, merely a matter of burning wax, a wick and the oxygen in the air. The hot air around the flame, being lighter than cool air, rises. As it does so, cool air flows in to replace it, and in turn becomes heated. Thus there is a steady supply of oxygen to the flame. Take away the pull of gravity, however, and the difference in weight between hot air and cool air vanishes. Nothing rises — hot air and the burnt waste products of the candle accumulate in a cloud around the flame. The oxygen supply is cut off.

And the flame goes out? Well, common-sense says that it should. But it doesn't. Somehow it simply 'goes to sleep'. If the pull of gravity is restored, it bursts into life again. In an aircraft, this has been tested for up to twelve seconds, but there seems no reason why the 'sleep' should not last longer aboard an orbital laboratory. And so one more piece of common-sense is turned upside-down when we look beyond the limits of our world.

There are many processes which are hampered by the fact that dense, heavy materials sink while lighter materials rise. Expanded polystyrene, foam rubber and similar products are made by creating bubbles of gas or air within substances while they are in a liquid state. When the liquid hardens, the result is a honeycomb structure combining lightness with strength. But when this process is applied to metals, the great difference in density between the gas and the fluid metal makes the bubbles rise towards the top of the mixture, instead of spreading evenly through it. Combining certain metals as alloys can be difficult, too, for differences in density make an even blending almost im-

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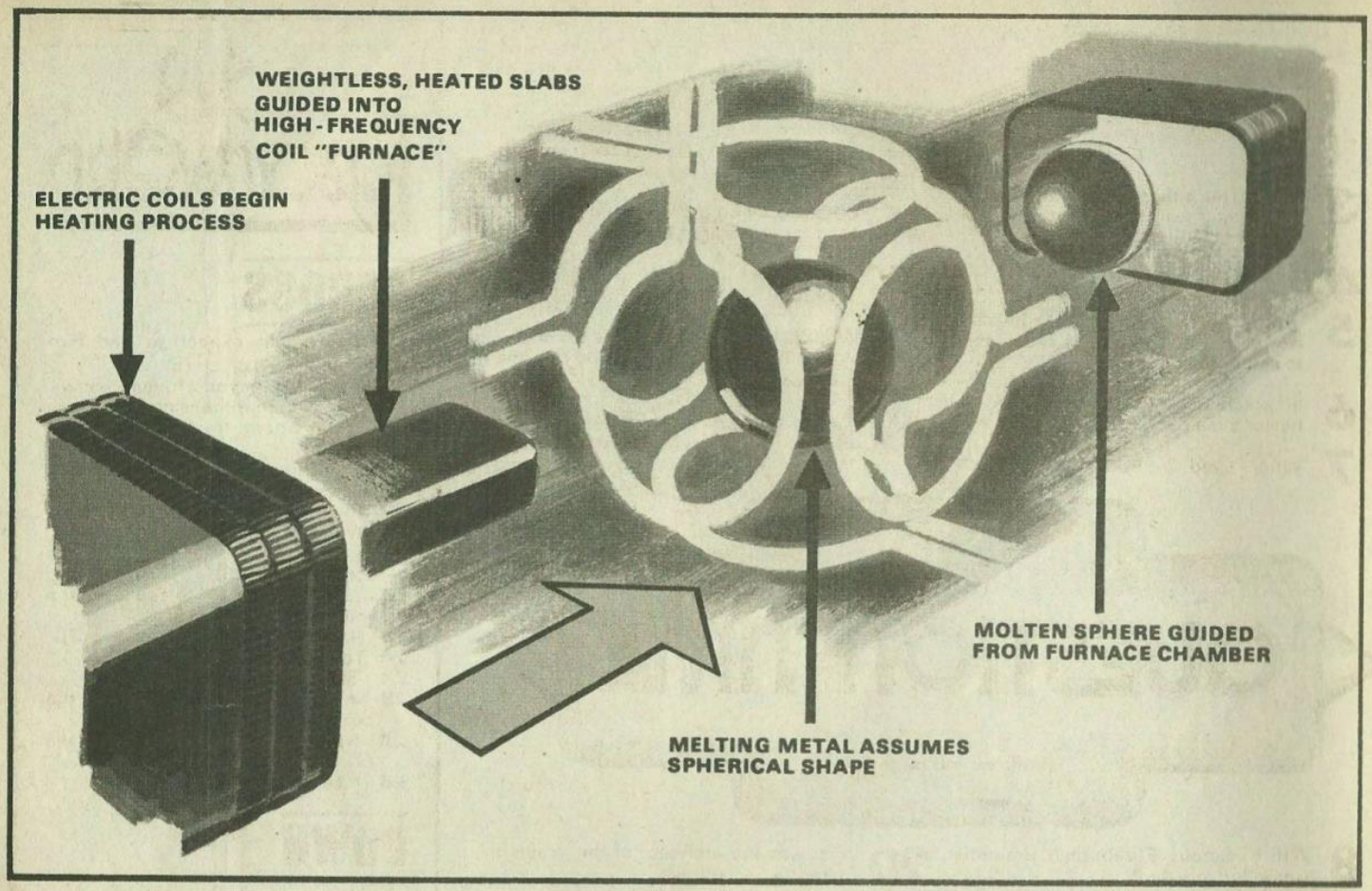

possible to obtain. In gravity-free conditions these problems would not exist.

Growing whiskers in space should be easier, although this has nothing to do with the astronauts' personal appearance. These whiskers are fine, but immensely strong, filaments formed from silicon and sapphire crystals. When not restricted by gravity, they should grow to lengths impossible upon Earth. Put into molten metal, they reinforce it, greatly increasing its toughness and strength. As with alloys, only weightlessness will get the best results from this process, for the whiskers do not mix evenly with the metal in Earth's gravity field.

Handling molten metal in space will be a tricky operation. Cold billets can be funnelled into the centre of an arrangement of high-frequency electric coils, which will generate the required heat. Floating in zero gravity in the furnace chamber, the billet will lose its rectangularity and become a molten sphere, the shape which all liquids assume when weightless. After this, it may be guided to wherever it is needed by means of electric currents. If the sphere should accidentally strike some object and splash, someone would face the interesting task of cleaning out a spacecraft interior filled with drifting droplets of hot metal.

Space makes these processes possible. It will also provide the metallic ores and many other substances needed by the orbital factories. Exactly where they will be found will be shown in the final part of this article, and also some of the things which we may have to do to save the Solar System.

Below: A space factory technician supervises the automatic working of a manufacturing process. The two priceless and free assets associated with a space factory would be total weightlessness and a perfect vacuum, such as is only achieved in space. Above: This diagram shows one way in which liquids (including molten metal) form perfect spheres in a weightless state, and could be used to form perfect ball-bearings for countless uses on Earth.

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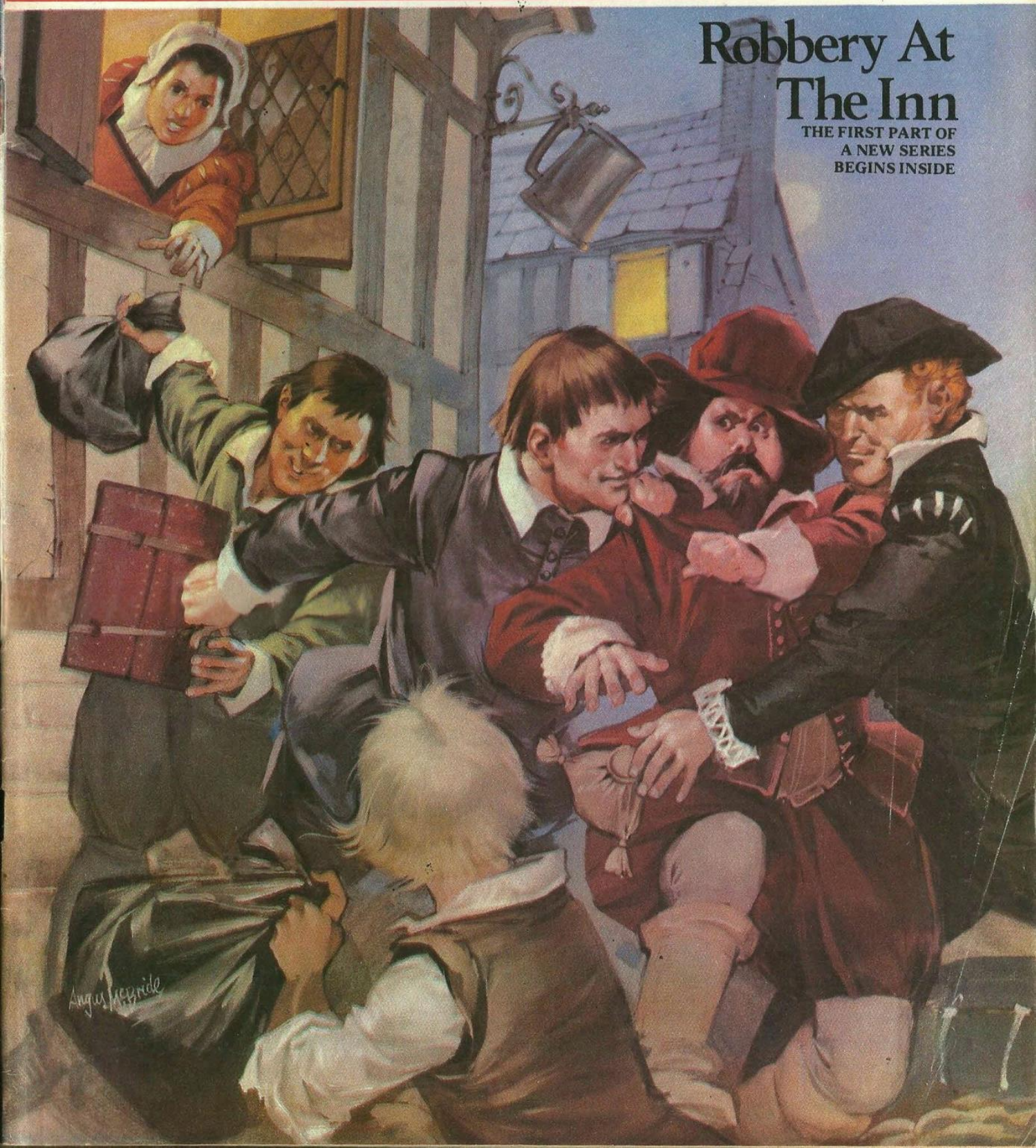
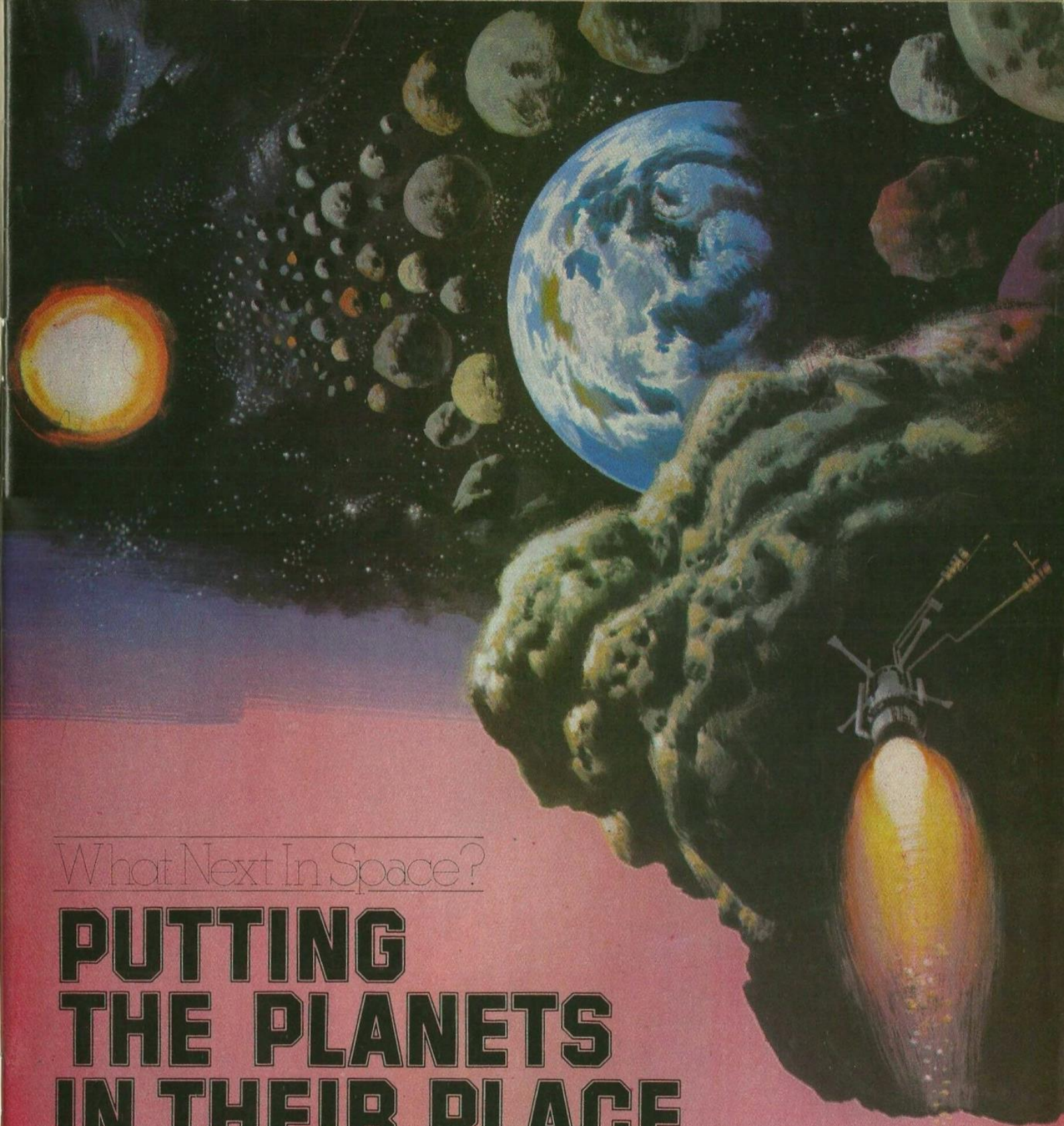


Robbery At The Inn

THE FIRST PART OF A NEW SERIES BEGINS INSIDE



What Next In Space?

PUTTING THE PLANETS IN THEIR PLACE

How can we capture the energy of the Sun? One scientist has suggested that we use space tugs to build a wall of asteroids and planets around this fiery mass to enclose all the wasted heat. And if that sounds like a job for Dr Who rather than a serious scientific proposal, remember that astronomers are already searching among the stars for other civilisations which might have had the same idea!

SPINNING around the Sun, between the orbits of Mars and Jupiter, is the greatest open mine in the Solar System, the Asteroid Belt. Masses of metal and stone, ranging in diameter from 450 miles to mere centimetres, the asteroids contain fantastic mineral

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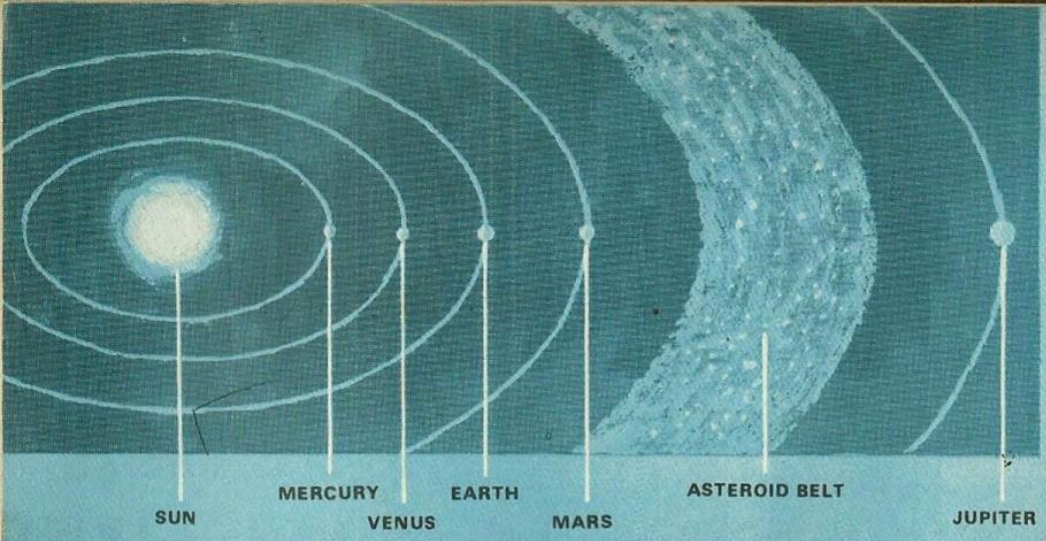
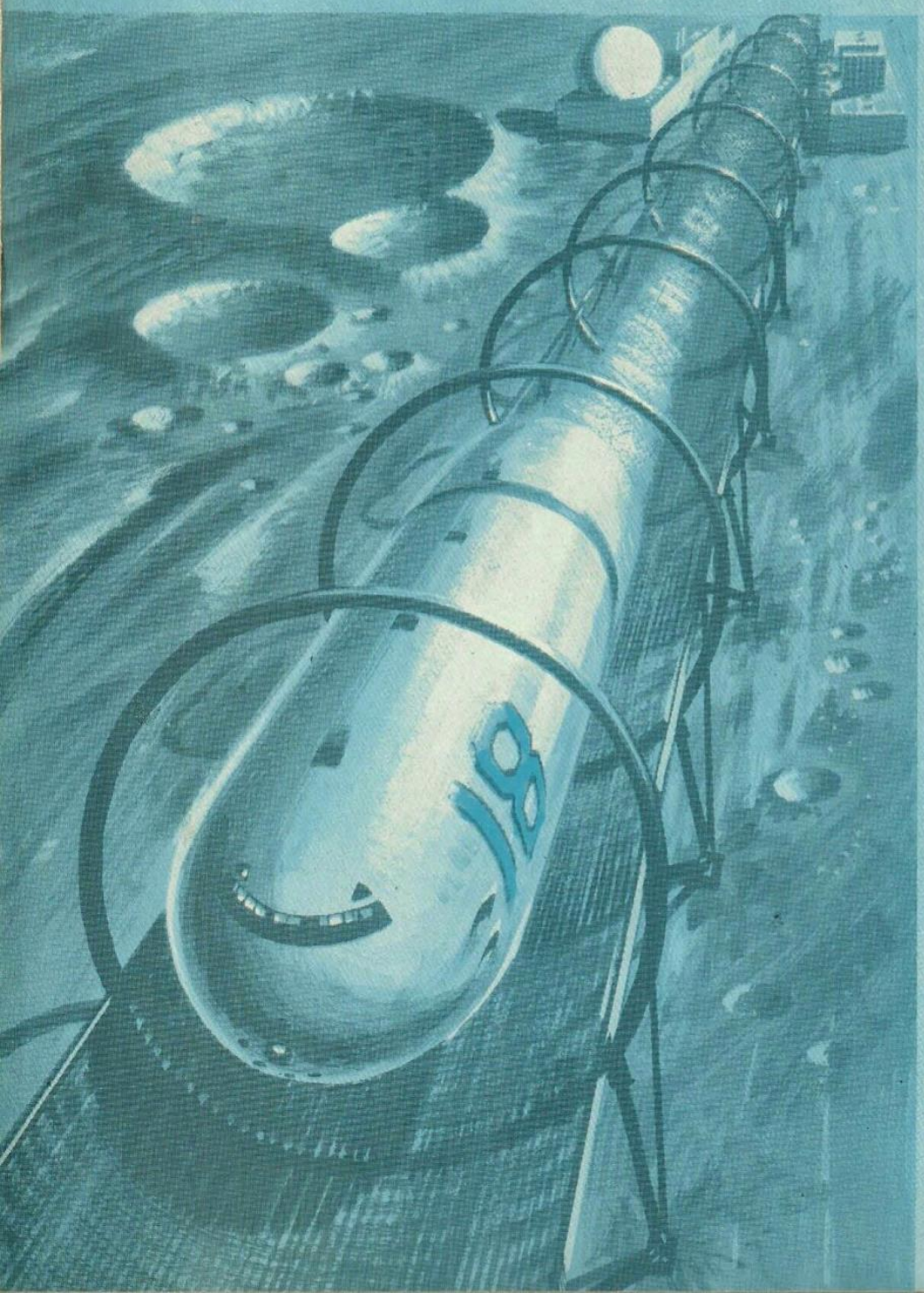


Above: A diagrammatic view of the Inner Solar System, showing the position of the main Asteroid Belt. Many asteroids within this Belt revolve around highly individual orbits. Below: One way in which we could take advantage of the Moon's low gravity to lift cargoes of ore and boost them on their way to Earth would be to use runways of electromagnetic coils to " push " vessels into space.



wealth. Lacking a covering of soil, and too small to have a fiery core which would make deep tunnelling impossible, their riches will be within easy reach. Some of them may be chunks of almost pure metal.

The old riddle about the weight of iron and feathers means nothing in space. An iron nail, a feather and a galaxy of one hundred thousand million stars are equally weightless. Once the ores have been mined and removed from the feeble gravity-pull of the asteroids, they would need little more than a push in the right direction to get them to the orbital factories. And the pull of even the largest asteroid, Ceres, is less than one-hundredth as strong as that of Earth. By using larger versions of the space tugs described in Part One (see Look and Learn, September 8th) of this article, entire asteroids may be shunted into long orbits which would bring them to the huge industrial satellites circling Earth and the moon.

MAGNETIC LAUNCHER

On the moon itself, many scientific and manufacturing installations will exist by that time. Where scientists need to make very delicate measurements and observations, they may have to site their instruments far away from refineries and factories to avoid pollution. Pollution on the bleak, sun-baked lunar surface may sound unlikely, but it will inevitably happen. Man may not repeat the short-sighted mistakes which have poisoned his home planet, but he cannot avoid the leakage of air, fluids and chemicals into space and the moon's dusty soil. And as the number of extra-terrestrial communities grows, so will the degree of pollution.

The moon can also be a source of raw materials for the orbital factories, particularly during the years before asteroid mining becomes possible. To lift quite large cargoes from a lunar installation will require none of today's clumsy, fuel-devouring rockets. For several decades, engineers have known that the moon's escape velocity, roughly one-fifth of Earth's, could be achieved by the use of electricity! On a long launching track, a metal-hulled space vehicle will hurtle towards lift-off, accelerated by a series of powerful electro-magnets placed at intervals along the rails.

SPACE FERRY

Such a vehicle might be little more than a huge canister, which could be collected by a space tug after being launched. Or it could be something more complex, a lunar ferry taking passengers back to Earth. Looking rather like the space shuttle, with delta wings and small rocket motors, this vehicle would coast into Earth orbit on the strength of an electro-magnetic boost. After that, the rocket motors would burn briefly, sending the ferry sliding down into the atmosphere on a long glide to a landing-field.

Will there be a market for the ever-expanding supply of perfect giant crystals, high-purity metals, new alloys, improved antibiotics and the million-and-

At the centre of the circling planets is the Sun, the engine driving the System's vast machine

one unguessable products that will come from space-borne industries? Without a doubt, the answer is yes. The industrial plants themselves will need many things which can only be manufactured in space. Twentieth-century technology increasingly makes use of materials which were once considered too rare and costly for mass-production methods. To build giant aircraft requiring heat-resistant skins of titanium would have seemed, not so long ago, as economical as making platinum dustbins. Yesterday's extravagance becomes today's necessity.

Yet we have scarcely begun to learn real extravagance. When our civilisation has absorbed the wealth of the asteroids and colonised the moon and Mars, and is reaching for the giant outer worlds, we shall be facing the next great step. In fact, we must take it in order to survive. It is nothing less than the re-arrangement of the Solar System.

UNTAPPED POWER

At the centre of the circling planets is the Sun, the engine driving the System's vast machine. Every second, the Sun burns away 4,600,000 tons of its own enormous mass, converting it into radiation. By the time that this expanding ball of energy reaches Earth's orbit, it is 186 million miles in diameter. To intercept it, Earth presents a daylight face measuring a puny 12,000 miles across. The total area of the combined sunward sides of every piece of matter in the Solar System absorbs only a minute fraction of it. Interstellar space swallows the rest.

Professor Freeman J. Dyson, of America's Princeton Institute, has suggested how we could capture and harness this escaping energy. We must build a wall around the Sun. With the techniques developed during the era of asteroid mining, the myriads of wandering fragments between the planets could be moved into orbits close to that of our own world. By pushing together masses of this space debris until they cohere under their own gravitational pull, planetoids could be formed large enough to be colonised. Gradually, a hollow globular shell as wide as the orbit of the Earth would enclose the Sun, soaking up the flood of radiation.

The inner face of this globe would be a spectacle unmatched by anything in nature. Although the whole sphere

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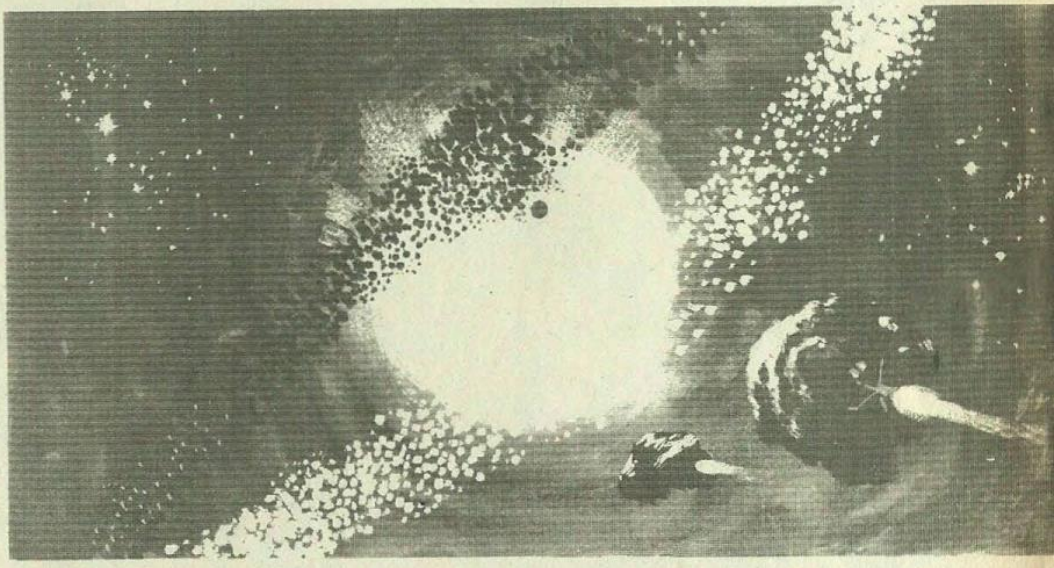
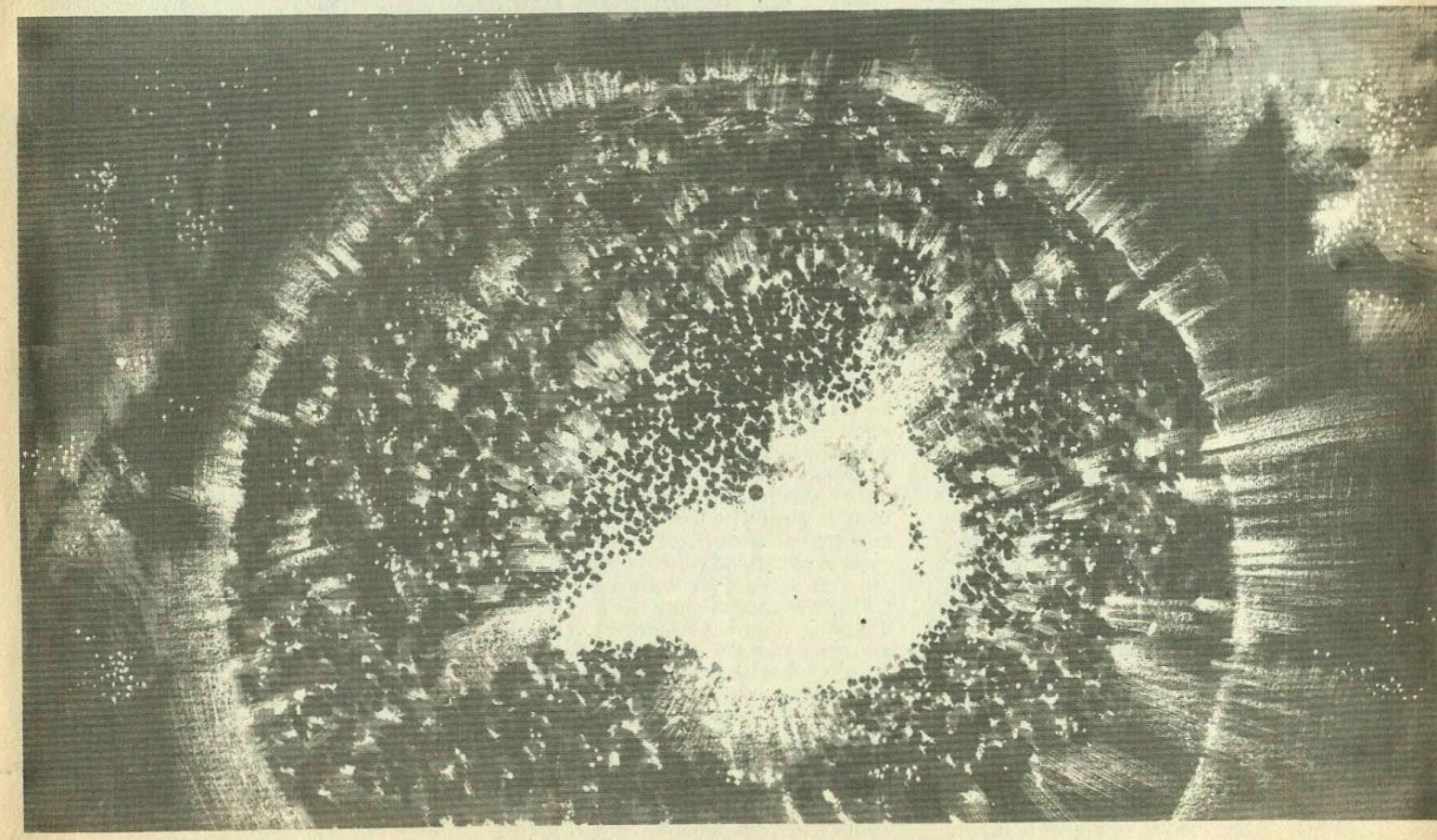


Two stages in the most incredible civil engineering project ever imagined by Man, the building of a "Dyson Civilisation." Above: The beginnings of an orbiting ring of asteroid material. Below: The almost complete shell around the Sun, absorbing its energy efficiently for the benefit of Mankind.



The crew of one of the Task Force ships from Earth have a grandstand view from the safe distance of several million miles as the mighty planet Jupiter begins its induced spin to destruction. The resulting debris would form the major part of a shell for our own " Dyson Civilisation."

would revolve about the Sun at a fixed speed, just as an illuminated geographical globe revolves about its inner light, each individual planetoid would also spin upon its own axis to create " night " and " day." The effect would be that of a colossal animated mosaic, winking and glittering as innumerable surfaces caught the light. Ghostly moons would crowd the daytime skies of Earth. On the night side of our planet, facing outwards from the dark surface of the shell, the stars of the galaxy would seem a pale and feeble display.

Because the total volume of these assembled fragments would not completely enclose the Sun, Prof. Dyson proposes to add the planet Jupiter. With a diameter of 88,000 miles, and a retinue of eleven moons, two of them larger than Mercury, Jupiter has a greater mass than all of the other bodies in the Solar System combined. By itself, it could provide enough material to build a sphere with walls roughly six feet thick, and an interior wider than the orbit of Mars. All that needs to be done to obtain this material is to wire up the planet's surface, feed it with vast quantities of electricity until it is rotating fast enough for centrifugal force to overcome gravity, and watch it fly apart. We can then move in and collect the pieces.

If all this sounds more like a job for Dr. Who than a serious scientific proposal by an internationally famous professor of physics, it should be pointed out that Prof. Dyson sees it as something to be done in the future, rather than today. Astronomers are already searching among the stars for signs of " Dyson civilisations," as these globes have been named. From outside, they will appear as dark spheres, their internal heat causing them to emit infra-red radiation invisible to our eyes, but detectable by instruments.

As America welcomes the return of Bean, Garriott and Loasma and prepares to send further teams up to Skylab for eight weeks at a time, the prospect of tearing apart giant planets seems faint and far off. Yet at the time that Bean was born, the creator of the V2 missile, Dr. Wernher von Braun, was building rockets with a peak altitude of less than 2,000 feet. Floating to earth by parachute as their fuel burned out, they were small enough to be caught by hand!

Within Bean's lifetime (and he is young enough to be an astronaut) we have gone from firecrackers to factories in space. We have proved that the future can be ours, if we will pay for it now, in the present.

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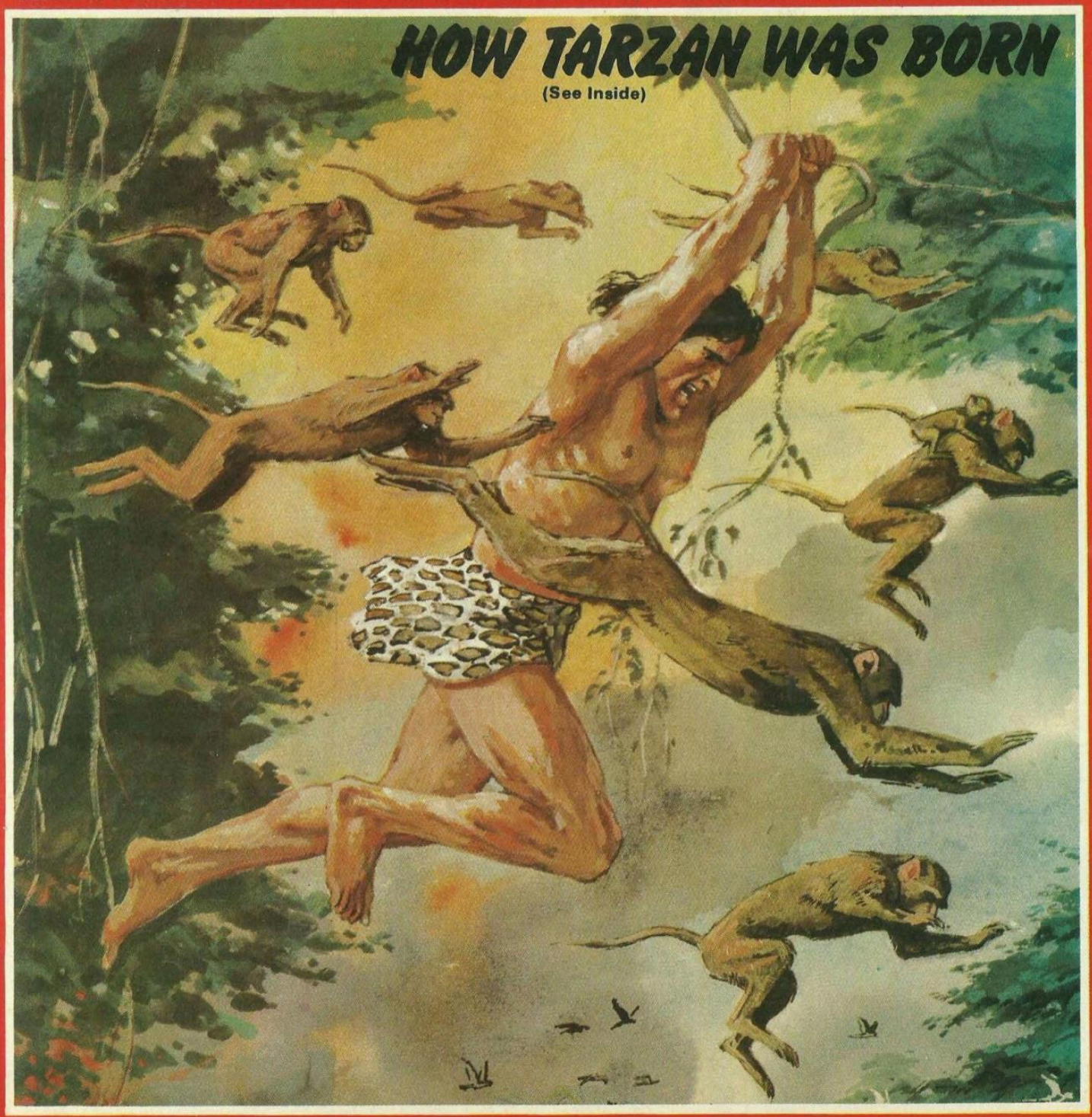


SCIENCE SURVEY

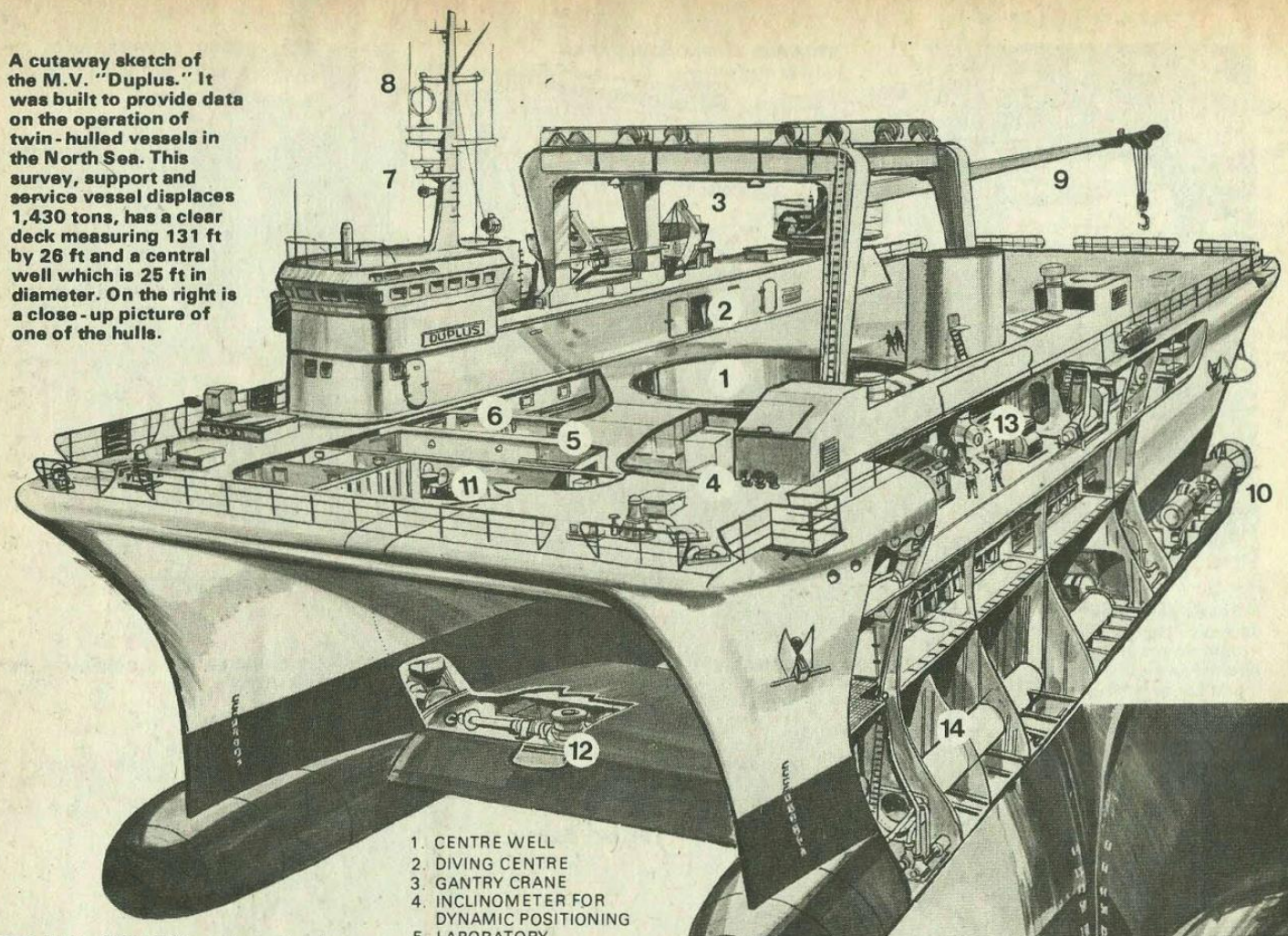
OIL ON TAP—PART 2

OIL IN TROUBLED WATERS

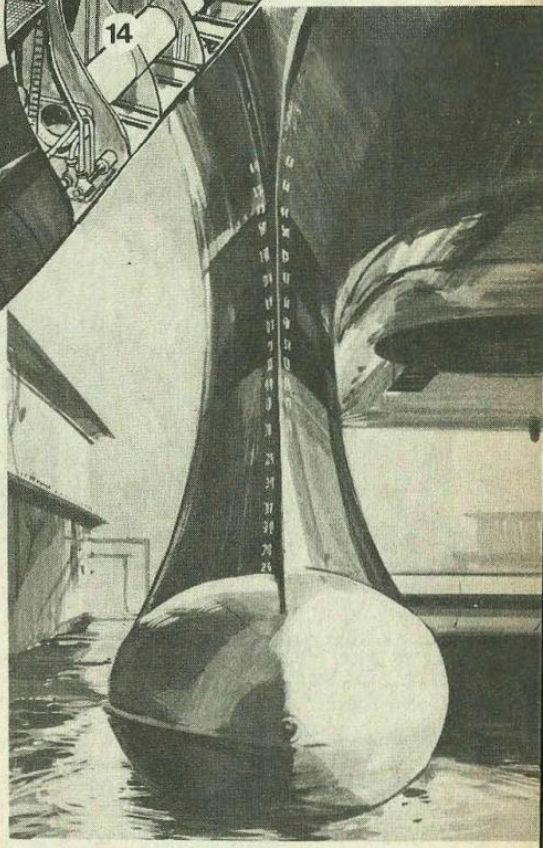
More than oil may be brought to the surface when the wells under the North Sea are in full flow. Also revealed to the light of day may be a host of problems that may tarnish the achievements of the oil explorers

Designed for work in the recovery of oil is the motor vessel "Duplus," seen here, which has been used as a support ship for divers and drilling rigs, for taking core samples and for geophysical and hydrographic work. It has twin-hulls for extra stability.

A cutaway sketch of the M.V. "Duplus." It was built to provide data on the operation of twin-hulled vessels in the North Sea. This survey, support and service vessel displaces 1,430 tons, has a clear deck measuring 131 ft by 26 ft and a central well which is 25 ft in diameter. On the right is a close-up picture of one of the hulls.



1. CENTRE WELL
2. DIVING CENTRE
3. GANTRY CRANE
4. INCLINOMETER FOR DYNAMIC POSITIONING
5. LABORATORY
6. RADAR SCANNER
7. CONSTANT TENSION WINCH FOR DYNAMIC POSITIONING
8. DIRECTION FINDER
9. REVOLVING CRANE
10. VARIABLE PITCH PROPELLER IN NOZZLE
11. CREW MESS ROOM
12. PROPELLER
13. MAIN ENGINE
14. BALLAST TANK



PALE-GOLDEN sand, washed over by tiny, fragile shells brought by the Gulf Stream from far, far away, lies in smooth stretches around the coast of the island of Lewis-with-Harris in the Outer Hebrides.

The weaving of Harris tweed from locally-reared sheep is, perhaps, the island's chief claim to fame.

But fame of a different sort is destined to shake the rural serenity of Harris and the other islands in the Highlands, for they are well-placed to play a central part in the oil industry that is likely to boom, before long, in the North Sea.

Instead of sea-washed beaches, with children building sandcastles, there may be huge machines scooping up this same sand to feed to mammoth concrete mixers for the construction sites, where oil rigs will be built, and jetties for the oil tankers.

Housing estates will be built for workers brought in from elsewhere. Speculators are buying up land for resale to the oil companies at a profit. Yards will be created for the building of oil rigs and tankers.

Oil rigs, about the size of Trafalgar Square in London, will be towed into place at sea and used for twenty to forty years, depending upon the life of the well beneath them.

Perhaps the concrete used in their construction will have come from a deep-water site on the west coast of Harris.

And after the platforms are no longer needed, the concrete may be broken up and the steel reclaimed.

The whole picture is of a busy, industrial Scotland. But there are a number of snags. One is that the industry will be temporary, because the supplies of oil are limited. Another is that the workers may be brought in from elsewhere, like the Italian experts laying a pipeline to Aberdeen. And another is that, when the boom is over, Scotland may be scarred by derelict, unwanted docks, industrial buildings and housing estates where there is no longer any work for the occupants.

All around the Scottish coastline are being developed a number of service bases. From here will sail the vessels which are needed for the seismic surveys, for towing and anchoring drilling rigs and for ferrying a wide range of supplies to the rigs and to other bases.

Most of the surveying and servicing of oil rigs has been done with converted or adapted vessels, originally built for other purposes.

This will change when vessels built for this specialised job come into service. Five are being built in Canada for use in the North Sea, and others are being built in Aberdeen and elsewhere.

Their design may be influenced by the findings of the operators of MV "Duplus," a twin-hulled survey, support and service vessel run by a Dutch company.

It was designed to provide data on the operation of twin-hulled vessels in the North Sea. She is a giant that displaces 1,430 tons, has a clear deck measuring 131 ft by 26 ft and has a central well

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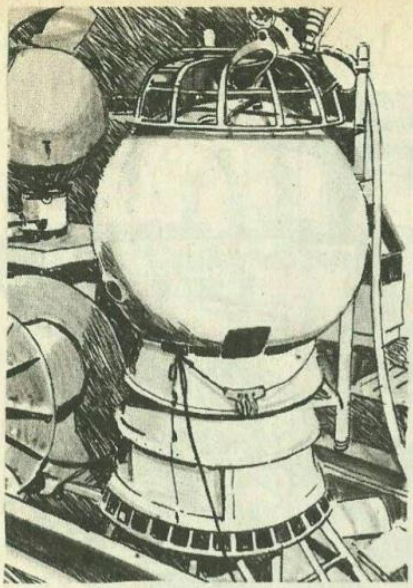
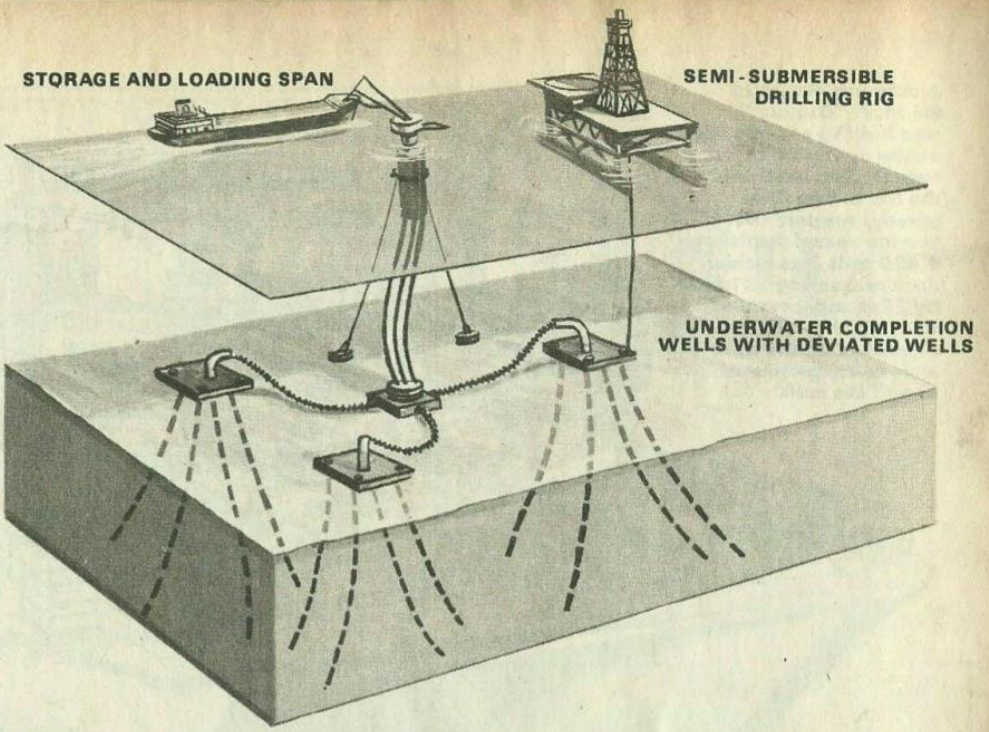
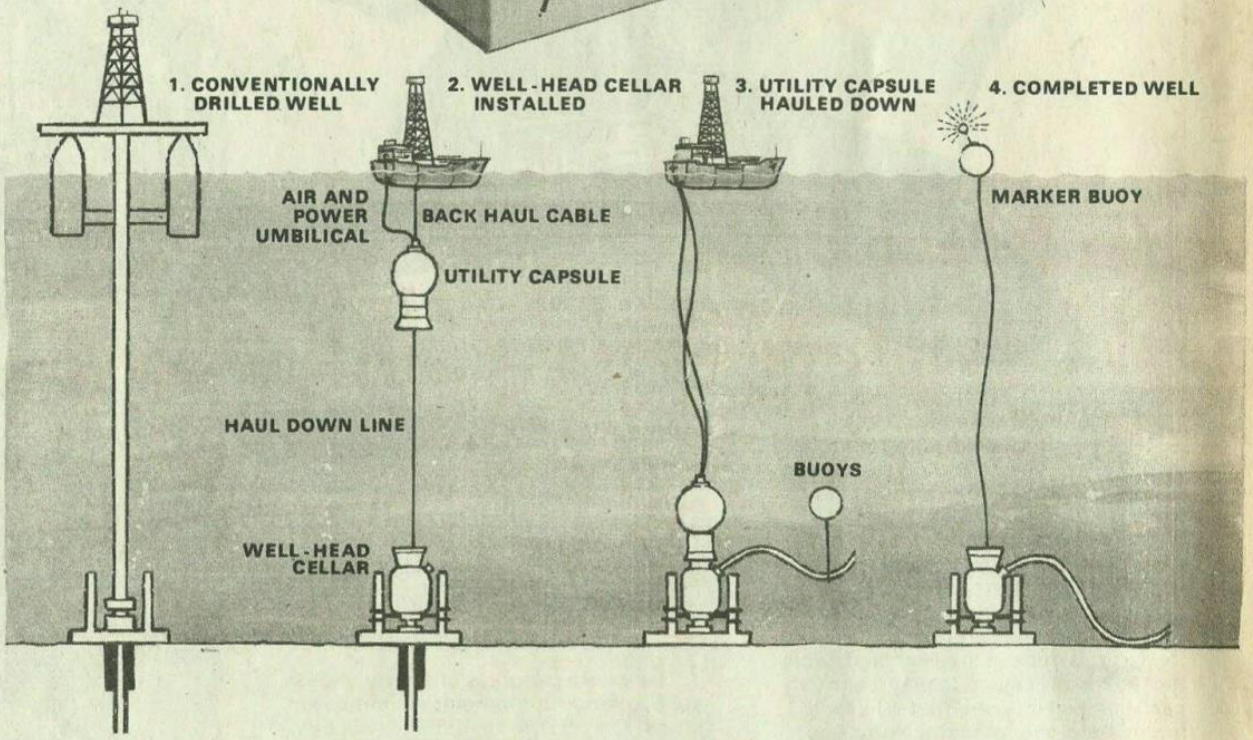




Above: a capsule in which men can travel down to the undersea well-head for servicing and maintenance. It has been tested to a depth of 900 ft. Above right: a system of underwater wells linked by pipelines to a buoy on the surface. These can be used in very deep water to avoid the need for a fixed platform. Right: a sequence of pictures showing how an underwater system is installed.



SCIENCE SURVEY

Continued

which is 25 ft in diameter.

On board is a 75 ton gantry crane, a 20 ton revolving crane, four anchor winches, an auxiliary winch and a salvage winch.

The owners of this vessel claim that it can maintain nine knots in a seaway, has a dry work deck usable under adverse conditions, and a working platform which is stable in all conditions.

She has been used as a diver-support vessel, a support vessel for a drilling rig, taking core samples and for geo-physical and hydrographic survey work.

There are two basic ways of extracting oil from beneath the sea. One is to bring the oil through a pipe to the surface where it ends at an oil production platform. From here, it can be loaded on to tankers.

The other is to complete the well on the seabed. One of the several systems being tested is the Lockheed subsea system. In this, well-heads on the ocean floor are contained in pressure chambers called well-head cellars, after the well has been drilled from the surface in the usual way.

The cellars are maintained at atmospheric pressure and, from them, oil can be delivered along pipelines to the shore or to the surface.

At the heart of this system is the service capsule, a kind of submarine, in which men go down to the ocean floor well-heads to carry out servicing and maintenance to them.

This is operated from a support ship which provides power, communications and air through pipes and cables.

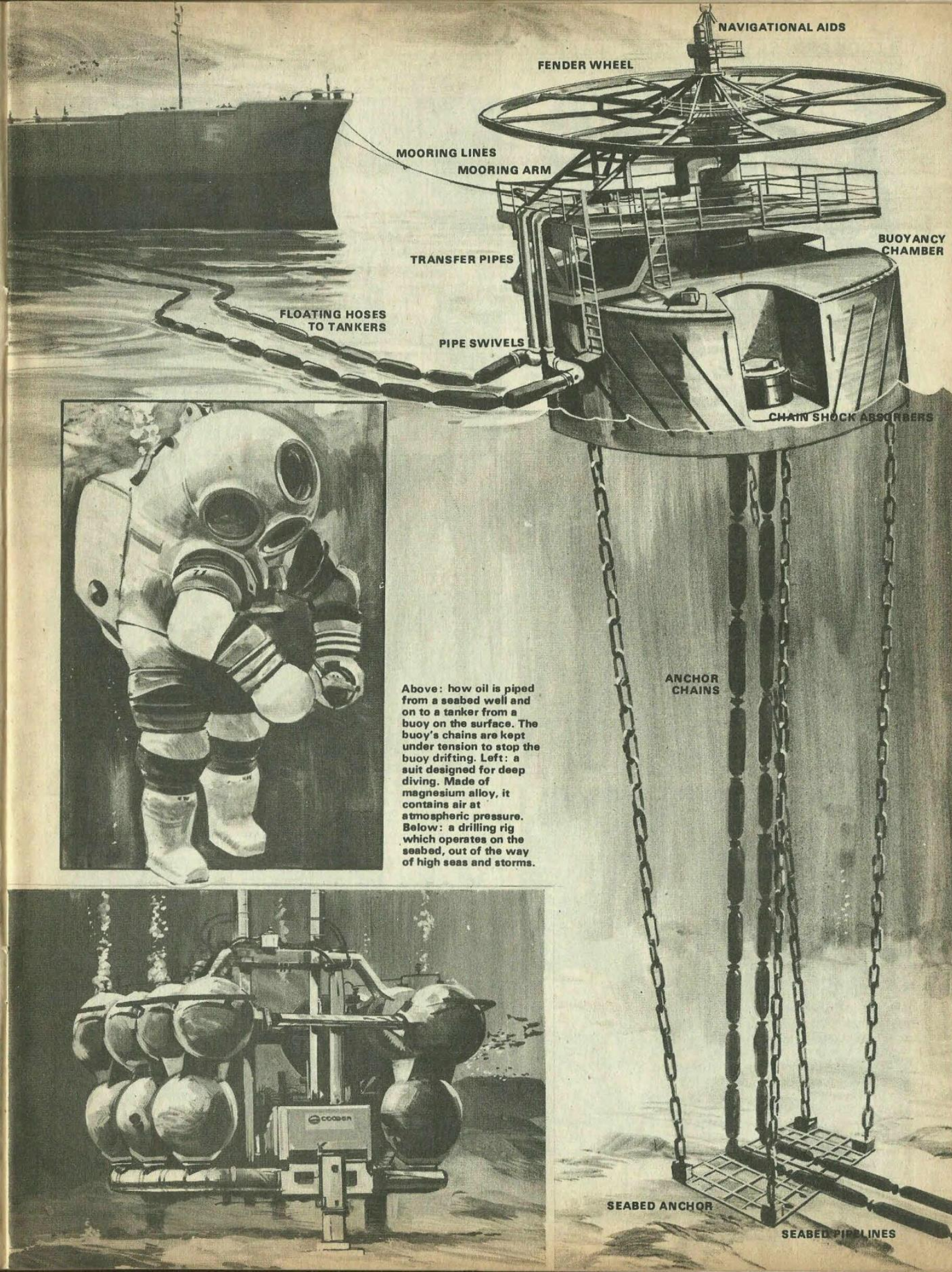
When supertankers arrive to collect oil, however, they may connect their pipes to a pick-up buoy, which serves as a connection with the well on the seabed.

It is secured to the seabed by four or six anchor chains. Its advantage is that it cuts out the need for undersea pipelines and the need to build harbours for the giant-sized tankers now being planned.

Critics say that the buoy system is as liable to spill oil on to the sea as is any other system. But one, known as the Woodfield, contains various refinements to overcome this risk.

But the advancements do not stop there. Inventors have perfected space-type diving suits maintained at normal atmospheric pressure despite the depths at which the diver is working, and submarine drilling rigs which work directly on the seabed.

All are playing their part in the North Sea oil boom. But only time can show whether it will be a blessing or a disaster.



Above: how oil is piped from a seabed well and on to a tanker from a buoy on the surface. The buoy's chains are kept under tension to stop the buoy drifting. Left: a suit designed for deep diving. Made of magnesium alloy, it contains air at atmospheric pressure. Below: a drilling rig which operates on the seabed, out of the way of high seas and storms.

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British Rail's HST prototype which has been running trial trips between London and Darlington since June this year and has tumbled the speed records for both steam and diesel with a run of 143 mph.

A LOOK AND LEARN SPECIAL FEATURE

The Super-Trains Are Coming

The first article in a two-part series about the exciting new breed of luxury high-speed trains which will spearhead Britain's rail revolution

"WE are running the Railway of the Future!" Who said that? Well, just about every country in Western Europe, plus America, during the past 20 years. A growing number of people are travelling by road, with the result that railway passenger services are losing money. At the same time, the increasing traffic is choking cities and motorways, so that road journeys are becoming more difficult and tedious. In an attempt to lure travellers back to the rails and clear up the congested cities, a wide variety of new transport systems are being tested. So many, in fact, that the answer to that claim could be: "Yes, but whose future?"

British Rail, who began a massive modernisation programme in 1954, could fairly claim that the future was theirs. The replacement of steam power by electricity or diesel units boosted average inter-city speeds to almost 80

CONTINUED ON NEXT PAGE

Inside the cab of the APT train. Ahead of the driver is the small windscreen and the main dials showing speed, acceleration and motor power, with the display panel of the monitoring system which keeps automatic watch on all important functions of the train. The left hand panel contains the cab controls, heating, lights, etc. The right hand panel is for the power unit controls

THE SUPER—TRAINS ARE COMING

mph, and made 100 mph top speeds almost routine. But this was only Stage One of the programme. While British Rail was scrapping steam — and making itself unpopular by closing down many lines and increasing fares — designers were working out the complex details of Stage Two. The result is the High-Speed Train, or HST.

A prototype version of the HST consisting of seven lightweight steel-shell coaches and two 2,250 hp. Paxman Valenta diesel units, one at either end, is running trial trips between London and Darlington. Within one week in June, 1973, it first broke the British rail-speed record and then the diesel world speed record previously held by Germany, reaching 143 mph on a later run on June 12th. The most remarkable thing about this double feat is the length of time during which the records had remained unbroken. The British record was established in 1938 by the 'Mallard,' an A4-class steam locomotive which reached 126 mph, and the diesel record in 1939 — 34 years ago!

Impressive as it is, the HST is still only one example of the new generation of trains being designed, built and operated by many nations. France runs two services which touch 125 mph, and has plans for a line carrying 185 mph trains. Germany and Russia are aiming at similar speeds. Japan has been ahead of the rest of the world for several years with the only line in regular service that was built solely for high-speed travel, the New Tokaido. Since 1964, services on the New Tokaido have regularly achieved 130 mph.

* * * *

Increased comfort is another weapon in the fight against the private car. Redesigned seating, improved dining facilities and air-conditioning on the HST will help to take the tedium out of long journeys. Connecting doors between coaches open automatically, operated by the pressure of passengers' feet upon the carpet as they approach. Anyone who has fought his way back from the buffet counter with both hands clutching cartons of hot tea, will appreciate this improvement upon the present doors. It will not be possible to open windows, for this would upset the constant temperature maintained by the air-conditioning system. Sealed windows, in fact, will be a necessary safety measure. At the HST's maximum operational speed of 125 mph, the airstream entering any open window would not be a gentle breeze!

This is the point at which new trains create new problems. As speed increases, so does air-resistance. It has been calculated that a ground vehicle travelling at 350 mph would need so much power to overcome air-resistance that it could never be run at a profit. Although this is far beyond anything yet planned, there are dangers even at lower speeds. A tunnel is not only a hole through a hill, it is also a buried cylinder of air, possibly hundreds of feet in length. When the solid mass of a fast-moving train hits one end of this cylinder, the air, con-

SOME CALCULATIONS SUGGEST THAT 350 MPH MAY BE THE APPROXIMATE LIMIT FOR A TRAIN. BEYOND THAT SPEED SO MUCH POWER WOULD BE REQUIRED TO OVERCOME AIR RESISTANCE THAT THE SERVICE WOULD BE UNECONOMIC.

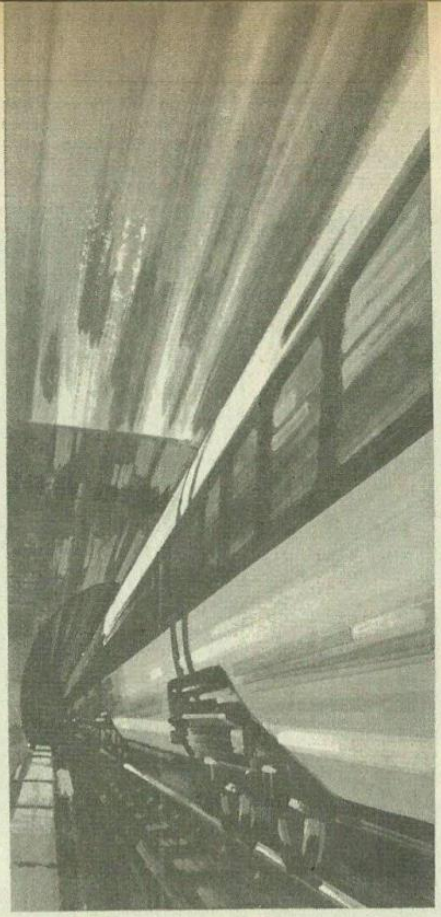
fined by the sides of the tunnel, is suddenly compressed. The faster the train, the more violent the compression. With trains moving in opposite directions within the same system, such large-scale projects as the Channel Tunnel have had to pay particular attention to minimising this effect. Even the comparatively slow London Underground makes allowance for increases in air-pressure when designing tunnel entrances.

Track, too, undergoes greater stresses and strains beneath the wheels of the new trains. Being first in the field with a high-speed line, the Japanese have learned this fact the hard way. The New Takaido was built to carry trains at 155 mph, but in actual practice it became so uneven that this had to be reduced to 130 mph. Hitting an uneven stretch of track at these speeds, even if it did not derail the train, could still create havoc among passengers and other movable objects. Britain, the pioneer of railways has a high proportion of old track in the network linking her towns and villages. Because of this, the HST was designed to operate safely within the existing system while running at 125 mph. Experiments with track laid upon concrete slabs instead of sleepers have shown that this combination allows greater accuracy when lining up the rails, and should also require very little maintenance. It seems probable that this type of permanent way will be used for future high-speed lines, together with improved signalling and automatic warning devices.

The latter will become essential by the time that Stage Three is reached and the Advanced Passenger Train (APT) comes into service. Because of its highly efficient suspension and braking equipment, the APT will be able, eventually, to operate at 155 mph on the present type of track. At this speed, a human driver cannot react sufficiently quickly to emergencies or swiftly-changing signals. This was another fact which the New Tokaido line taught the Japanese.

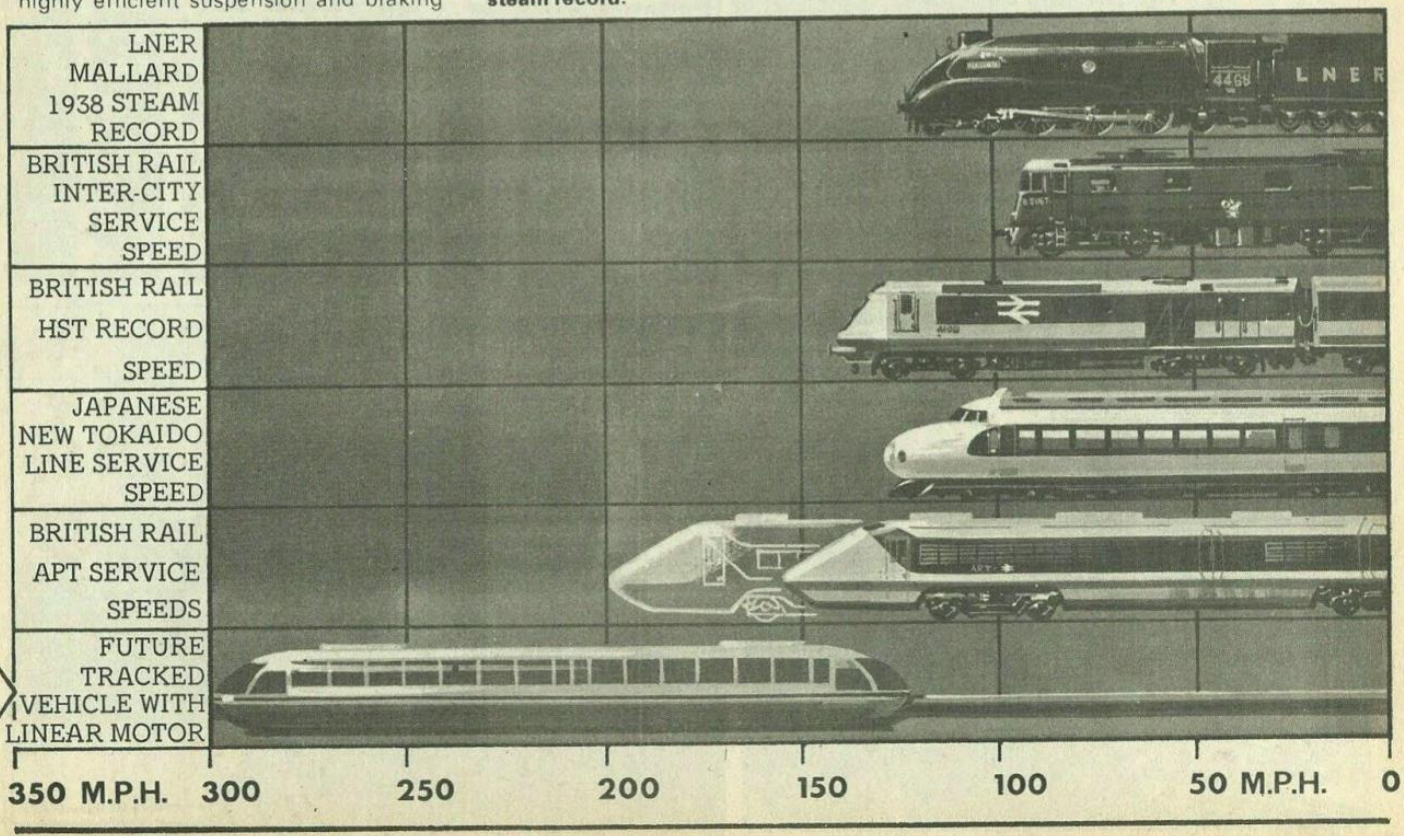
Automation is the obvious answer. It is already used in several transport systems, notably the Bay Area Rapid Transit railway in California and London Underground's Victoria Line. Every aspect of the Bay Area service is handled by computers, and the only function of the 'driver' is to sit around waiting for something to go wrong. Victoria Line men are allowed to press a few buttons, but their situation is basically the same. By the time that the APT is on its first regular route between London and Glasgow, possibly in the late 1970s, British Rail should have gathered a great deal more information about the limitations of drivers at high speeds. Looking a little further into the future, the APT will almost certainly run on lines reserved exclusively for the fastest inter-city services. Building such trains is an expensive business, and to operate economically they must be allowed to make the maximum use of their speed potential. This cannot be done when sharing the permanent way with slower traffic. So, looking like metallic dragons with their sleek sides and out-thrust snouts, the APT's will race between the cities, beaming invisible radar pulses at the track ahead to register their speed.

British Rail designers see no reason why speeds cannot be pushed up to 200 mph, or beyond, with later versions. For really rapid transportation, however, we may have to take the wheels off the trains! But that is next week's story.



One problem of very high speed operations is the sudden compression of air which takes place when the train enters a tunnel. Such pressures could smash carriage windows and create enormous and very damaging air turbulance.

Below: A comparison of some of the record and service speeds of Today and Tomorrow, compared with the 1938 steam record.



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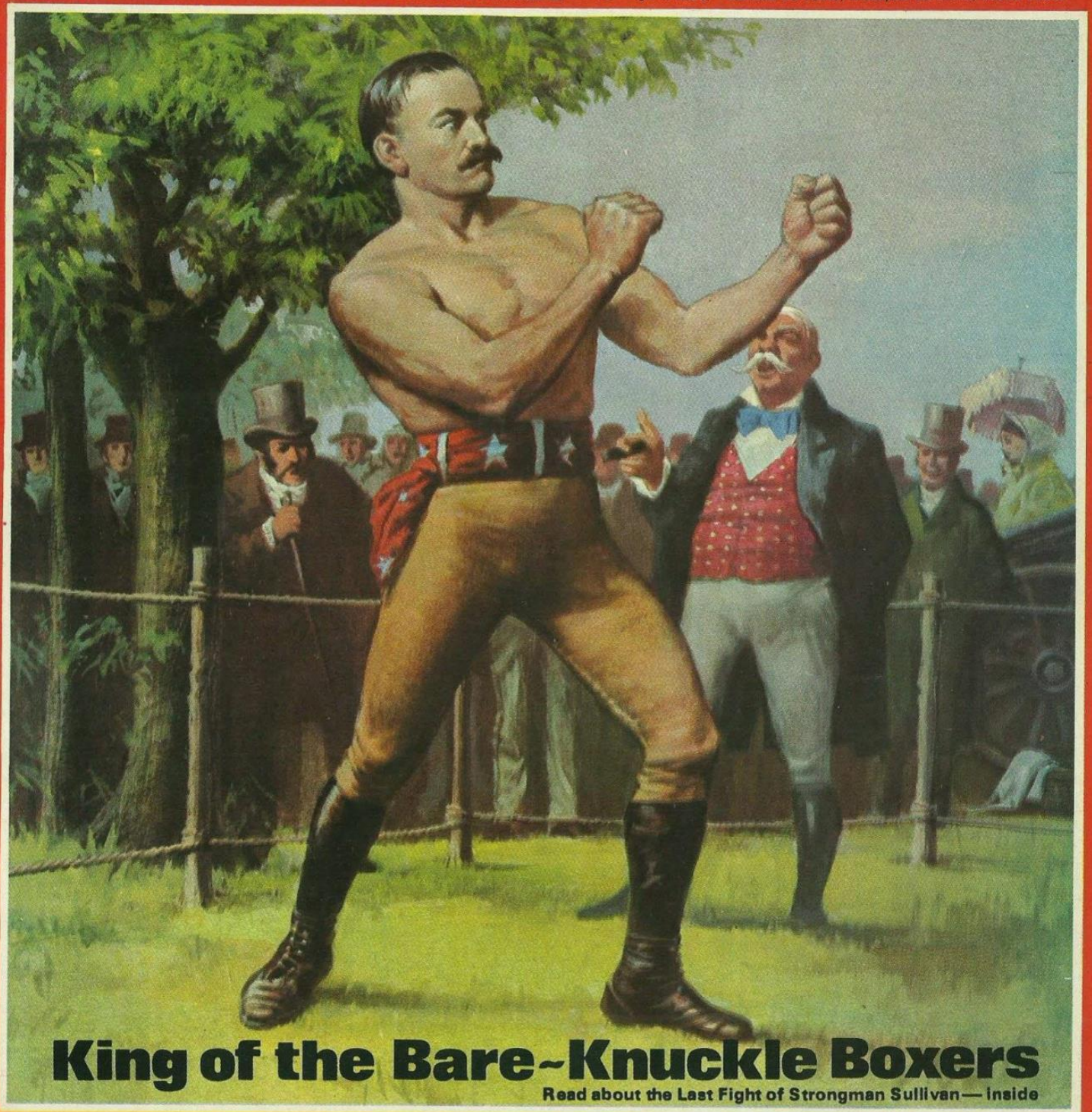

King of the Bare-Knuckle Boxers

Read about the Last Fight of Strongman Sullivan — Inside

British Rail's Advanced Passenger Train at high speed. Although highly modified the APT is still a conventional wheeled locomotive running on conventional track, and facing the problem of decreasing wheel adhesion the faster it travels. The experts say that for speeds up to 200 mph the APT design is adequate, but beyond this limit the problems of wheel adhesion, resulting in loss of driving power and stability, become so great that a wheel less tracked vehicle will be necessary.

CONCLUDING OUR TWO-PART SERIES ABOUT THE LATEST IDEAS AND DEVELOPMENTS IN THE DESIGN OF HIGH-SPEED TRAINS FOR THE FUTURE.

A LOOK AND LEARN SPECIAL FEATURE

Magic Carpets For Commuters

Supported and propelled by immensely powerful magnetic forces, tomorrow's 350 mph trains - without - wheels could make dreams of a Magic Carpet ride come true for weary commuters

A diesel locomotive is a massive brute, a slab-sided power unit weighing perhaps 100 tons. Standing on 12 wheels it looks as if nothing short of another diesel locomotive could move it. Yet each of those wheels touches the track with only a tiny segment of its tread. The total area of contact supporting that 100 tons is no greater than the area covered by a ballet-dancer poised on tiptoes. And the 2,000-plus h.p. developed by the power unit must be transmitted to the rails through those contact points.

Adhesion, the grip which the wheels have upon the track, weakens at high speeds. As a result, the power of the locomotive is not efficiently transmitted. The wheels spin without pushing against the rails. No one yet knows at what speed a total loss of adhesion will occur, but many engineers think that the more advanced types of high-speed train are getting close to the limit. Before the limit is reached, they hope to have perfected a power unit in which the push is independent of the wheels, or to have dispensed with the wheels entirely.

Of all the forms of wheel-less vehicles currently being developed, the hovercraft is

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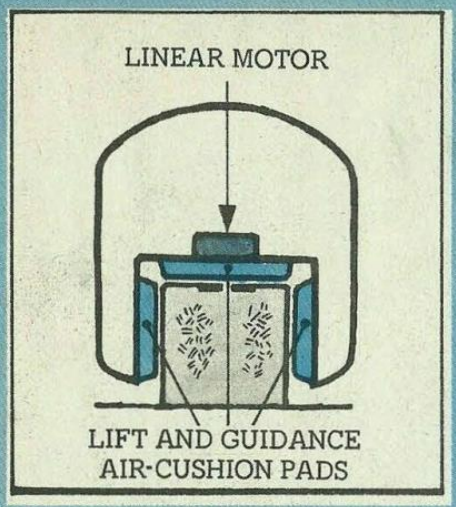
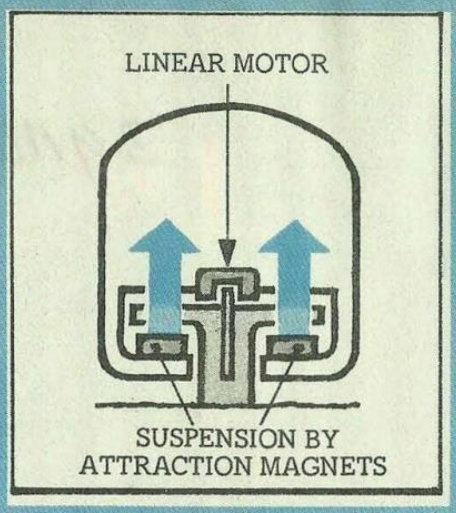
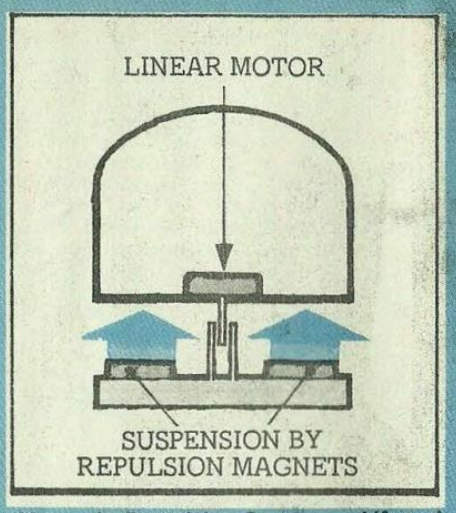
Magnetic levitation or "mag-lev" is the next logical step in high-speed train design. Working on the principle that like magnetic forces repel each other, the train would "float" above the surface of a single track line, supported and propelled by magnetic forces that repel. Here the principle is demonstrated in a laboratory with electro-magnetic coils keeping an aluminium plate suspended in mid-air by such forces.



These simplified diagrams show how some of the wheel less trains work. Tracked Hovertrain System — Lift and guidance provided by air cushion pads. Propulsion by linear motor.



Magnetic Attraction System — Lift and guidance provided by magnets. The train is attracted upwards towards the underside of the track. Propulsion by linear motor.



Magnetic Propulsion System — Lift and guidance provided by magnetic forces repelling train from track. Propulsion by linear motor.

Magic Carpets for Commuters Continued

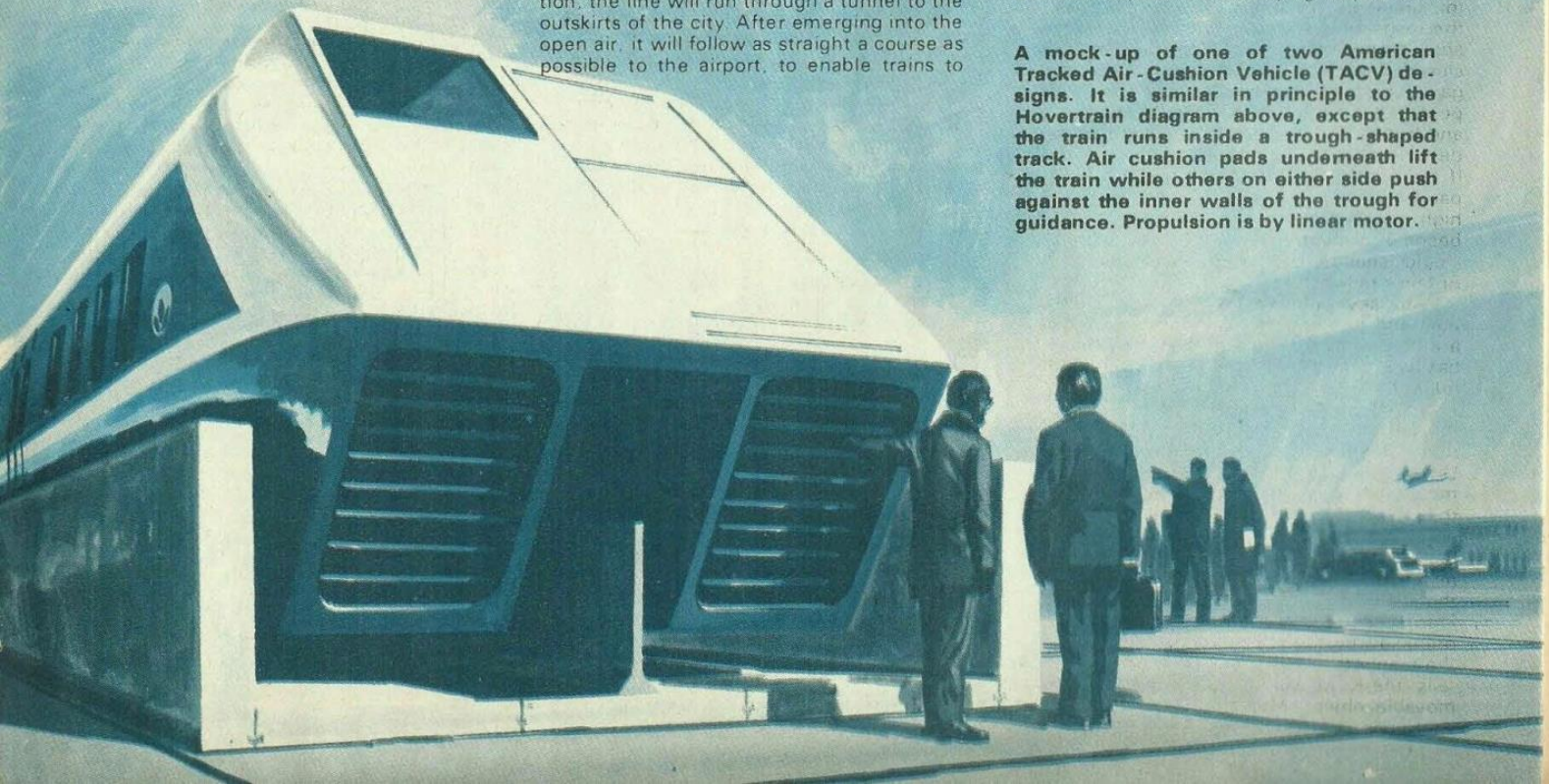
the most widely known. Two years ago, a test site was set up in Cambridgeshire to experiment with a track-borne version, the Hovertrain. This vehicle combines the lifting power of the hovercraft's air cushion with the propulsive force of a linear motor. Very little of the layout bears any resemblance to a conventional railway. The track is a concrete wall which fits into a groove in the lower half of the Hovertrain, so that the upper, passenger-carrying section rides along the top of the wall while the air-pads for steerage hug the sides. Seen end-on, it looks rather like a stubby clothes-peg on a washing-line. Although the experimental RTV.31 never achieved more than 106 m.p.h. on the short test track, it was hoped that 300 m.p.h. could be reached by future long-distance versions. That hope was killed when the Government decided that the advantages of the Hovertrain did not justify the cost of building an entire new track system. It was the end of the Hovertrain, but not of the linear motor.

The principle of the linear motor is extremely simple. In magnetism, positive charges repel positive, negative repels negative. Therefore, if a vehicle with powerful magnets fitted to the underside is placed on a track which has a metal strip laid between the rails, directly beneath the magnets, then the strip will become magnetised. The vehicle and the strip will repel each other, and so the vehicle will be pushed along the track. In the case of the Hovertrain, the strip, or 'reaction plate', was laid along the top of the concrete wall and was of steel protected by a covering of aluminium. There is nothing new about the basic idea, for the first work on linear motor-driven vehicles took place before the 1914-18 War. Modern developments in electronics and other fields have made the dream a practical reality.

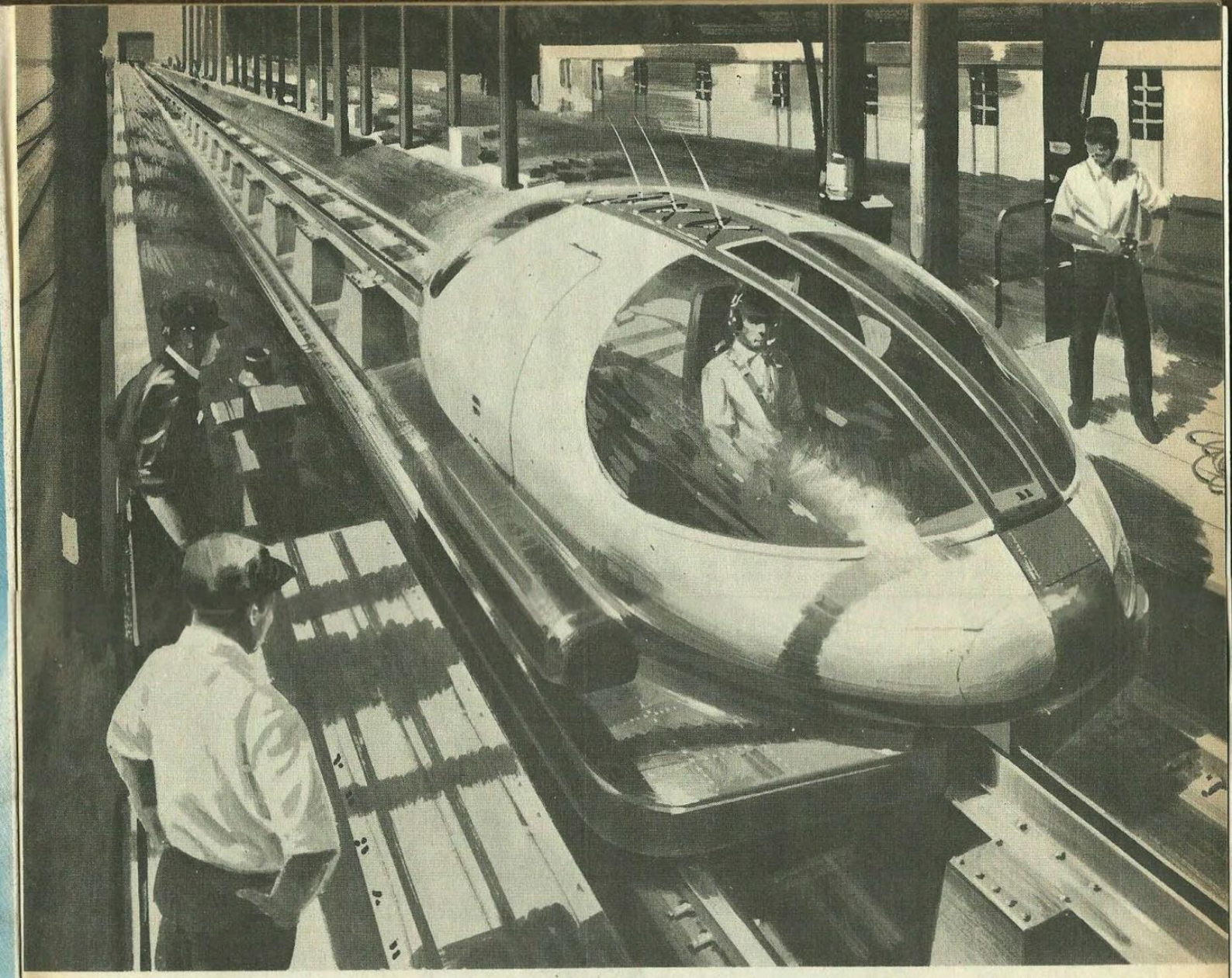
The first linear-powered passenger service to be seen in Britain will probably connect London with Foulness Airport, on the Essex coast. Beginning at King's Cross Station, the line will run through a tunnel to the outskirts of the city. After emerging into the open air, it will follow as straight a course as possible to the airport, to enable trains to achieve maximum speed. British Rail expects this maximum to be 250 m.p.h., but over the total distance of 52 miles the average speed will be nearer 160 m.p.h. when acceleration and deceleration times are included. Coaches originally built for the Advanced Passenger Train will be adapted for use on the line, making it the fastest wheeled service in the world. Control will be entirely automatic, and the trains will be driverless. How willing people will be to travel at high speeds without a human hand on the brakes remains to be seen.

* * * *

The same pre-1914 series of experiments produced an even more revolutionary device, magnetic levitation. As the name indicates, "mag-lev" uses the repulsive or attractive powers of magnets to suspend a vehicle in mid-air. Used in combination with the linear motor, it is the scientific equivalent of a flying carpet. Like



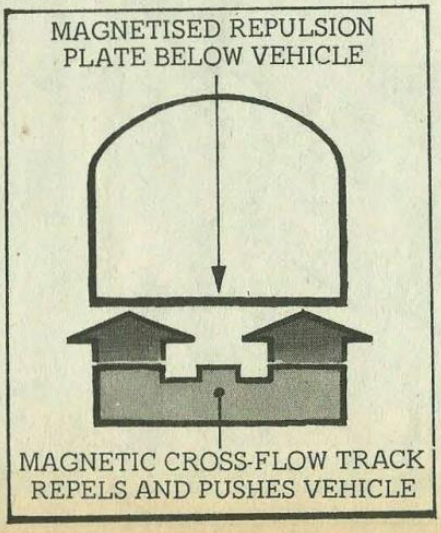
A mock-up of one of two American Tracked Air-Cushion Vehicle (TACV) designs. It is similar in principle to the Hovertrain diagram above, except that the train runs inside a trough-shaped track. Air cushion pads underneath lift the train while others on either side push against the inner walls of the trough for guidance. Propulsion is by linear motor.



the linear motor, mag-lev had to wait for the technology of today to make it a workable proposition. When the Government closed down the Hovertrain project, they gave grants of several hundred thousand pounds to the Hawker Siddeley company and British Rail, to continue working on the development of linear motors and mag-lev. If the Cambridgeshire test site can be expanded and given enough track to enable high-speed trials to be carried out, it could become a centre for experiments which would change the whole appearance of Britain's railways.

With several mag-lev vehicles actually built and in operation, Germany and Japan are considerably ahead of Britain. Germany has two types, the beetle-like Krauss-Maffei, or K-M, and the angular Messerschmitt. The K-M runs on a raised concrete track, the top of which is wider than the base, so that it resembles a very long dining table. Under the projecting edges of this top, metal rails are fitted. The vehicle is wider than the track, and its lower sides, which are equipped with magnets, curve inwards just below these rails. When power is fed to the magnets, they are attracted to the rails. As they rise, they lift the entire vehicle. Floating in magnetic suspension, it can then be propelled by the linear motor. Obviously, if the magnets actually make contact with the rails, the K-M will become a distinctly immovable object. Maintaining the small but vital gap between them, especially at speed, calls for an elaborate electronic system.

Above: This four-seat linear motor test vehicle is the forerunner of a Japanese train for 1980 which will travel at over 300 mph. It uses a magnetic repulsion system to lift and float the train 2½ inches above the track. Below: The simplest and most effective design for the future — the "Magnetic River" system in which the magnetic track provides levitation (by repulsion) guidance and power for forward speed.



Both the K-M and Messerschmitt use attractive forces. The Japanese version will use repulsion, floating above a trough-shaped track. Magnets set into the walls of the trough will repel those in the base of the vehicle, pushing it upwards. Because repulsion requires more power than attraction, these magnets will be superconducting.

When certain metals are cooled to minus 269 degrees Centigrade by immersion in liquid helium, they lose all resistance to electrical currents and become superconductors. Because of this lack of resistance, power fed into magnets made of such metals is used with a very high degree of efficiency. Thus they can be lighter and smaller than conventional magnets of the same strength. Handling liquid helium on board the vehicle may create difficulties, however.

With all of the above still in the experimental stage, it may seem odd to suggest that they are already out of date. If a new system designed by Britain's Prof. Eric Laithwaite and Dr. Eastham can be applied to full-sized vehicles, this could be so. Christened the "magnetic river", it combines the functions of linear motor and mag-lev by both lifting and propelling.

One thing is certain. Whether the future of land transport belongs to wheels or magnets, the coming of the super-trains is not far away.

35 ST LUBE

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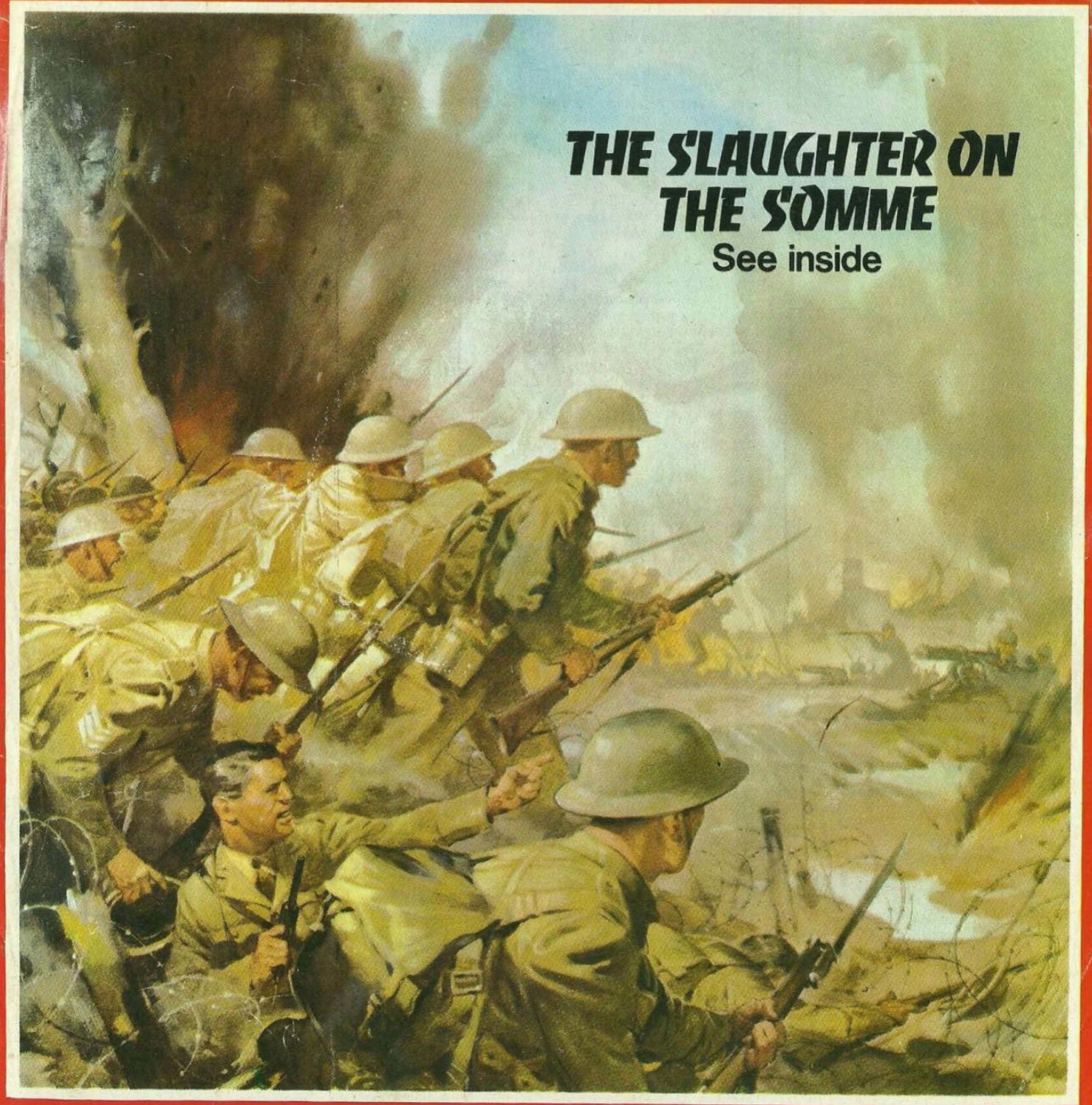


THE SLAUGHTER ON THE SOMME

See inside

A LOOK AND LEARN SPECIAL FEATURE

Skyport-2001

Texans have a reputation for thinking BIG, and no more so than when it comes to building an international airport, for by the year 2001 the newly-opened Dallas-Fort Worth air terminal will be the largest complex of its kind in the world

Above: The looped terminals at the new Dallas-Fort Worth airport have been designed so that passengers will only have to walk some 200 yards from the car park to the place where they actually board the aircraft. Right: This artist's impression of the airport shows seven of the giant looped terminals. By 1980 13 such terminals will deal with a total of 15 million passengers a year.

LIKE everything else in Texas, the airport being built amid the plains near Dallas is big. Very big, indeed. It has to be for this breath-taking complex of criss-crossing runways, terminal buildings, highways, hangars and bridges has the undeniable stamp of the 21st century. Completion date is the year 2001. Then the Dallas-Fort Worth Regional Airport will be the biggest in the world.

Yet, although more than 25 years will have passed before the airport of the future is finished, it is already operational. It was opened officially in September with a special guest of honour: Concorde 002.

The supersonic airliner, carrying the colours of both British Airways and Air France, had zoomed at twice the speed of sound across the Atlantic to Caracas Venezuela. After re-fuelling, Concorde 002 sped north, throttled back to a mere 700 miles an hour when the US coast appeared and began the descent to the airport that looked like a string of athletic stadiums below. On board were the heads of British Aircraft Corporation and Aero Spatiale with their team of top salesmen, hoping that after three days of demonstration flights American airline chiefs would submit big orders for Concorde.

* * * *

The celebrations marking the airport's inauguration certainly heralded a new era in the science of handling millions of air travellers.

Britain and France hoped the great occasion would also usher in the age of supersonic jetliners.

Mr Thomas Sullivan, the airport's executive director, who once held the title of Deputy Director of Aviation for the Port of New York, estimates that 60 million passengers a year will use the Dallas-Fort Worth airfield by 2001. Then it will have 13 terminals with 234 "gates," each capable of handling a Jumbo 747 jetliner. The cargo of more than 200 aircraft will be handled with ease and efficiency by two fully-automated cargo centres. In fact, the airport will be able to cope with more freight than any seaport in the world. There will even be runways for short take-off and landing aircraft.

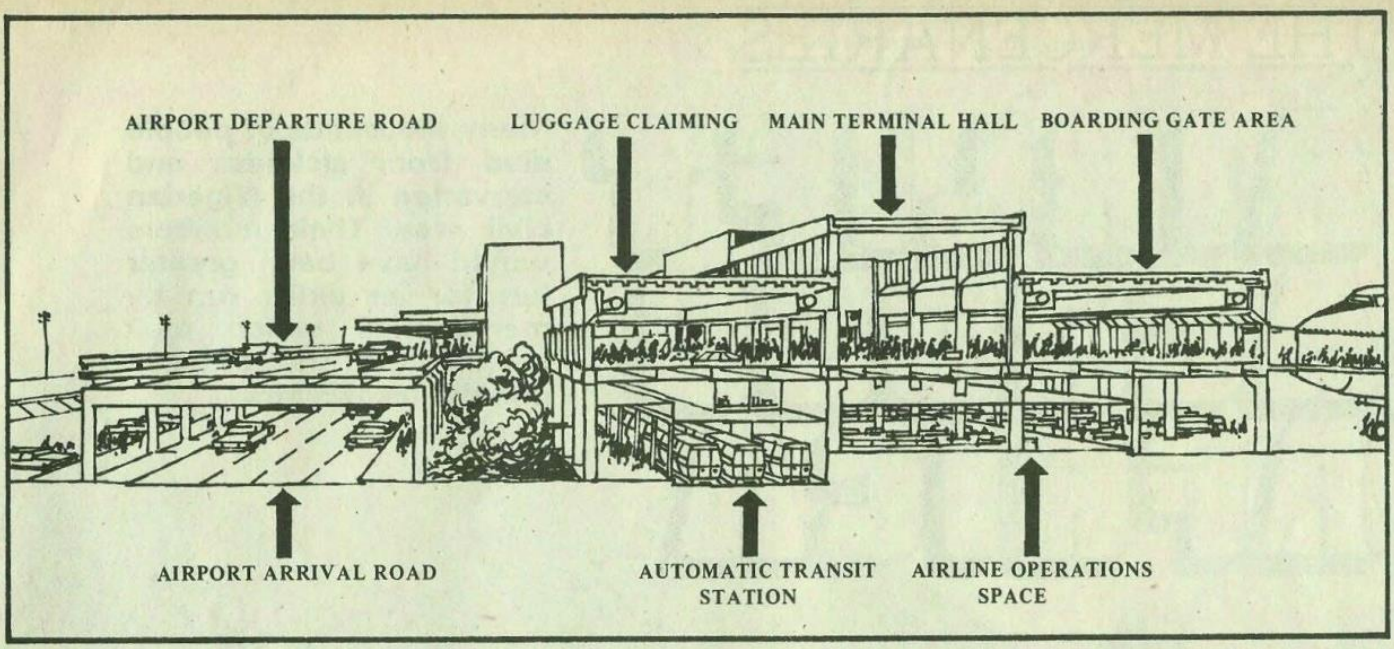
During the past two years alone, 300 airport designers from 50 nations have visited the site rising like an oasis among the shrubland of Texas. Already, it has given hundreds of jobs to engineers, architects and other technicians at a time of economic hardship in the

CONTINUED ON NEXT PAGE

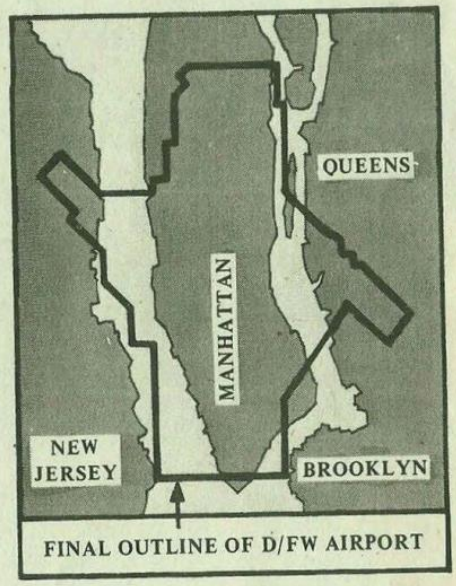
AOL

Skyport~2001

Passengers will be able to move between terminals by car or by an automated transport system called "Airtrain," the first of its kind in the world. Running in concrete guideways, these 17 mph vehicles are driverless and are supervised from one control centre. Each vehicle will carry 16 seated and 24 standing passengers, plus baggage.



Above: A cross-section of the interior of a typical terminal area at the new airport. Below: The enormous size of the complete airport, as it will appear in the year 2001. Here its outline is superimposed on a map of the city of New York. In figures, the area will be 17,000 acres or some 26 square miles.



US. It is estimated that ultimately 47,000 new jobs will have been created among 40 manufacturing and service industries. It guarantees a boom period for Dallas and Fort Worth at least until 1975 with about £200 million pouring into industries around the two cities.

Today, Dallas-Fort Worth airport has already cost £280 million, a figure that will be multiplied many times over before it becomes fully operational in 2001.

The statistics are already immense. In its first year, more than eight million passengers are expected to pass through the luxurious transit lounges on their way to airliners, although only four terminals and three runways will be functioning. By 1980, the number of passengers will be around the 15 million mark.

The Texas airfield covers 17,000 acres or 26 square miles, which makes it bigger than the island of Manhattan and three times as large as New York's Kennedy Airport. In the years ahead, it will grow to dwarf not only Kennedy Airport but the other two New York airports — Newark and La Guardia — as well.

The new super airport grew from the realisation that the one serving the two Texas cities, which lie 20 miles apart, at Love Field would reach saturation point by 1975. So the planners dreamed of creating an air city that would cater for short-range schedules as well as meeting the demands of the next century.

But before the first designs appeared on the drawing boards, the growing needs of air travel in the decades ahead were computerised. It was, indeed, in the skies above Dallas and Fort Worth that the airport's framework first took shape.

Estimates of the thousands of aircraft that would fill the air lanes were fed into a computer to be reconciled with the number and length of runways needed to clear them. Then the number of feed-ways leading to the runways and taxi-ing areas was worked out and from these figures the number of "gates" and terminals for passengers was gauged. The computers also came up with the number of car parking spaces which would be needed by 1975 — 20,000!

As the map of the super airport grew, the designers did not ignore the experience provided by the world's airports over many years. Basically, the idea was, strangely enough, to return to the essential element of the early days of commercial aviation when a passenger arrived at an airport in his car, parked it, walked across to a nearby terminal building for his ticket and then stepped straight on to an airliner waiting on the nearby runway.

Over the years that simple idea has been overwhelmed by the huge structures, connected by endless corridors, that airports have become today.

* * * *

The Dallas-Fort Worth airport has one significant difference from the early ones. The terminals will be grouped in the first stage of development to form four semi-circular terminals, each 3,000 feet long and linked to a central highway. As passenger demand grows more "half-loop" terminals will be added to the highway. The design will mean that only a few hundred feet will separate a car park from a passenger's waiting airliner.

In precise terms, any passenger arriving at Dallas-Fort Worth will walk no further to his airliner than he would in walking the length of a jumbo jet . . .

But if he wants to inspect the airport complex itself, he will find it has its own internal transport system of electrically powered vehicles, which can carry him to any destination in a few minutes.

Apart from passenger consideration, the planners also debated the environmental aspect of future air travel. Noise would have to be cut down to reasonable proportions. So they have ensured that by the year 2001, the north and south boundaries will be three miles from the main runways and crosswind runways will be two miles from the airport perimeter, in this way, a large "buffer" zone will be created to muffle the roar of jets for people living nearby.

While in its initial stage the airport will serve only the north of Texas, it is destined to link up Europe and Asia with frequent non-stop services. The ultimate ambition will be achieved when no country will be more than 14 hours flying time away from the airport, which itself is only a 20 minute drive from Dallas and Forth Worth. The main cities of the US will then be a mere three hours "flip" away from the mammoth State of Texas.

Action-Packed Fact and Fiction

48 PAGES

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No. 624, 29th DECEMBER, 1973
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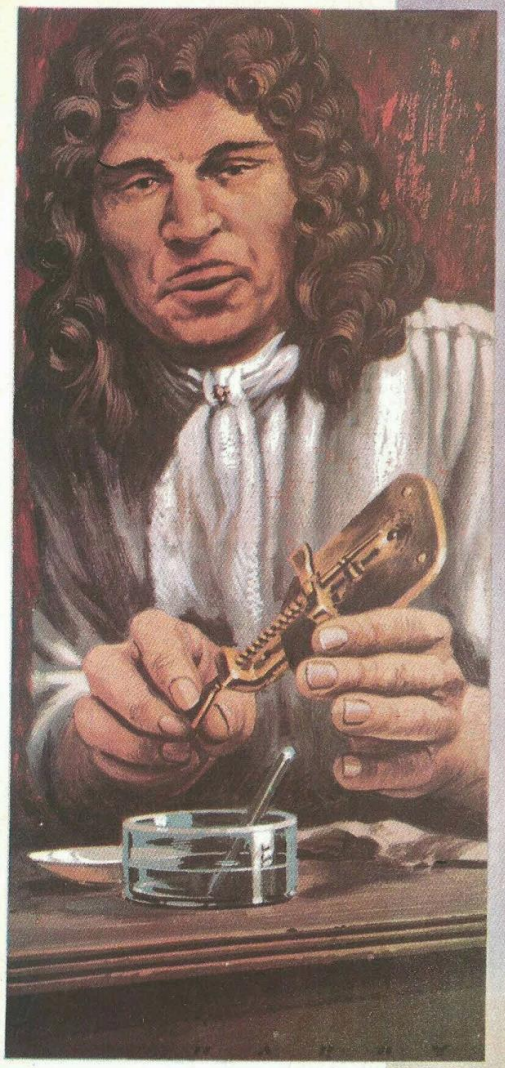


SCIENCE SURVEY

SEEDS FROM THE STARS

What is the multi-million year secret of life? What are our origins? Some chemical reaction, perhaps, which provided the building blocks for our race? Or is there, amid some twinkling galaxy, an advanced civilization which 'seeded' our young planet with organisms as an experiment, and has long since forgotten to check the results?

TWENTY years ago, two American scientists mixed ammonia, methane, water vapour and hydrogen together in liquid water, and subjected the result to an electrical discharge. What they hoped to obtain from this unpleasant chemical soup was some clue to the origin of life on Earth. In a later experiment the electrical discharge was replaced by ultraviolet light. The light and the electricity represented the Sun's radiation. The chemical soup, poisonous though it sounds, was an attempt to duplicate conditions on the surface of our planet when life began.

The Earth of that distant age was an alien world. A time-traveller arriving there would find a landscape of lava and naked rock lit by the flare of erupting volcanoes. No living thing would be visible on land or sea. Without life-support equipment, the time-traveller would suffocate in an atmosphere thick with volcanic gases and devoid of oxygen. Lacking oxygen, there would be no protective layer of ozone to screen off the deadly flood of ultraviolet radiation from the sun. The higher organisms of today, including ourselves, could not survive in such conditions. Nevertheless, most scientists now believe that they were the conditions which created life. The question is, how?

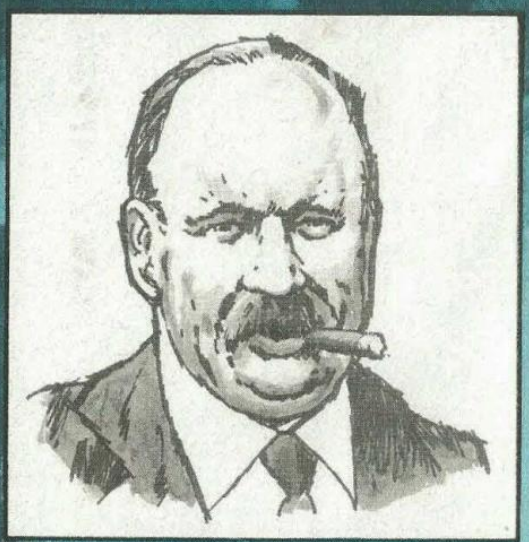
Until the 17th century, it was thought that living creatures could evolve directly from non-living matter. Maggots and flies were believed to be formed in rotting meat. Two men, working many hundreds of miles apart and unaware of each other's researches, helped to disprove this idea. In Italy, Francisco Redi used what we now call the scientific method to examine the origin of flies. Flies, he saw, settled on rotting meat before maggots and other flies emerged from it. Could there be a connection? He put pieces of meat into several jars, leaving some jars open and covering the necks of the others with gauze. When a new crop of maggots appeared, they were in the open jars, the only ones in which flies could settle on the meat to lay their eggs. The meat in the covered jars remained dead meat and nothing more.

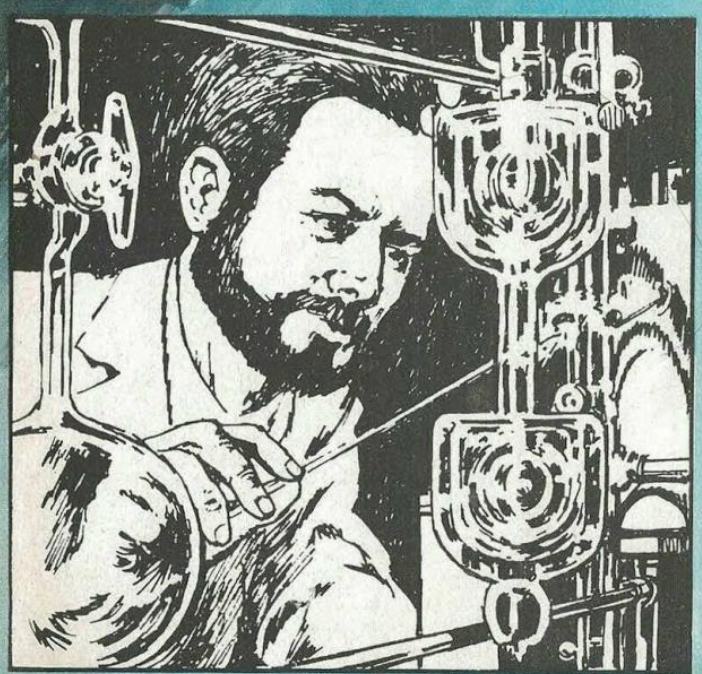
While Francesco Redi was carrying out his experiments, a Dutchman, Anton van Leeuwenhoek, was perfecting an instrument which would have greatly simplified Redi's work. Using the world's first microscope, van Leeuwenhoek discovered that a single drop of water held millions of tiny organisms. Even more amazing was the fact that liquid which was boiled until these organisms were dead, would be

CONTINUED ON NEXT PAGE

Three hundred years ago, men of skill and imagination were already unlocking the secrets of life invisible to the naked eye. The Dutchman, Anton van Leeuwenhoek (above) made the first simple but effective microscope by grinding and polishing his own lenses and became the first man to observe the bacteria in a drop of water.

But how did life begin on Earth? Did an advanced race dispatch a robot craft (right) across the galaxy to "seed" young, bubbling volcanic planets like Earth with living organisms?





The Swedish scientist, Svante Arrhenius (top) has suggested that Life might have spread across the Universe in the form of tiny spores, transmitted by the light of stars. However, recent experiments (above) have shown that micro-organisms would not survive for more than a month in the vacuum of space.

swarming with them once more when it had cooled. At first this seemed additional proof that life could form spontaneously, but later researchers discovered that the new organisms entered the cooled liquid from the surrounding air. Finally, in 1860, Louis Pasteur proved that these microscopic bacteria were actually the cause of decay, not the result. After thousands of years, spontaneous generation had been discredited. Less than a century later, scientists revived it to explain the origin of life on Earth.

* * * *

When the Americans, Dr. S. L. Miller and Dr. Harold C. Urey, examined their chemical soup after several days of bombardment with ultra-violet, they found organic substances present. They were not living things, but they were the basic 'building blocks' from which life might be formed. It was an encouraging beginning. The picture of a primitive Earth absorbing the fierce energy of the sun and using it to convert lifeless chemicals into ever more complicated structures, began to take shape. Critics of the picture pointed out that a complicated chemical structure was still very far from a living organism. To expect life to somehow happen by accident was being extremely optimistic. Enthusiasts replied that Nature had a thousand million years, or more, in which to arrange her building blocks. A lot of accidents could happen in that span of time. Unsatisfied, some of the critics turned to the work of a great Swedish scientist, Svante August Arrhenius.

Arrhenius, winner of a Nobel Prize for chemistry, was one of the first scientists to realize that light from a star exerts pressure on objects in its path. As an example, he pointed to the ghostly, fan-shaped tails of comets, which invariably stream away from the Sun, blown outwards on a wind of light. (The new comet, Kohoutek, will demonstrate this spectacularly before the end of 1973.) The theory which captured the imagination of the general public and became the basis of countless science-fiction stories, before and after Arrhenius' death in 1927, sprang from its observation. It was Panspermia, the spreading of life from world to world by tiny seeds, or spores, propelled through space by the pressure of starlight. One such spore, drifting down through the harsh atmosphere of a lifeless Earth, might have triggered off the multi-million-year process that led to Man.

Unfortunately for this fascinating idea, we now know that the radiation encountered in outer space would almost certainly kill any unprotected spores. The new version of Arrhenius' theory overcomes this difficulty by suggesting that life may have been sent to our world deliberately, aboard a spaceship. We may have already done this within our own solar system, unintentionally. In addi-

Ammonia, methane, hydrogen, water and radiation -perhaps it was this noisome chemical soup which contained just the right ingredients to make Mankind

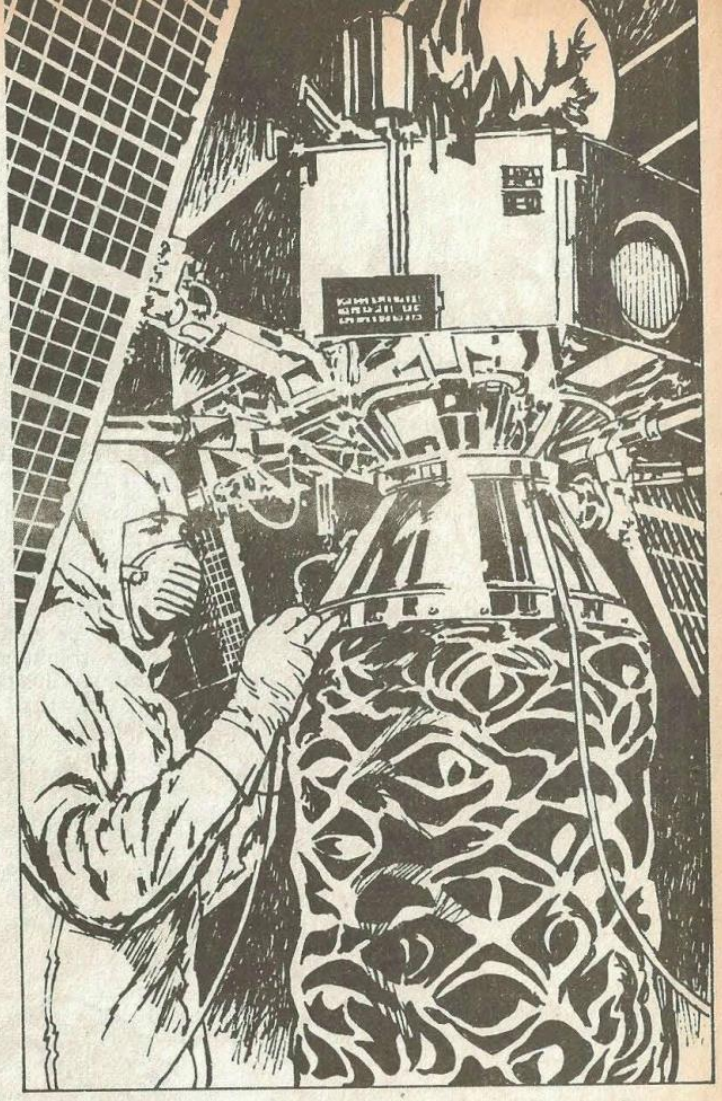
tion to the astronauts who landed there, America is estimated to have put at least one hundred million micro-organisms on the Moon. Russian space-probes, lost beneath the clouds of Venus, may have infected that planet. In both instances, this happened because we could not completely sterilize all of the equipment carried into space. It is unlikely that bacteria will survive on the lunar surface, but we cannot be certain about Venus.

* * * *

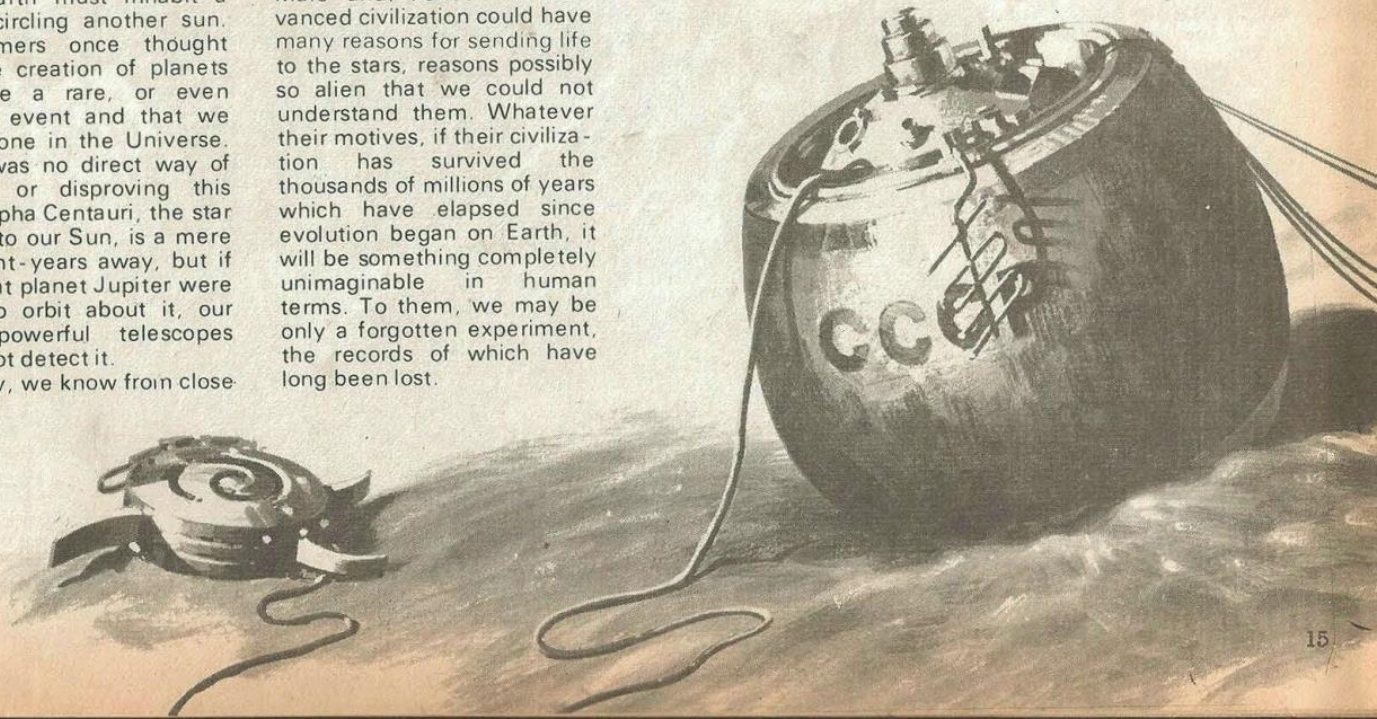
Because it is generally accepted that there are no other intelligent beings in the solar system, the supporters of the new-style Panspermia look to the stars. The race which despatched a ship to seed Earth must inhabit a planet circling another sun. Astronomers once thought that the creation of planets must be a rare, or even unique, event and that we were alone in the Universe. There was no direct way of proving or disproving this idea. Alpha Centauri, the star closest to our Sun, is a mere four light-years away, but if the giant planet Jupiter were put into orbit about it, our most powerful telescopes could not detect it.

Today, we know from close observation that the movements of several stars are being affected by the gravitational pull of smaller, unseen, bodies. Calculations show that in the case of two of these stars, 61 Cygni and Lalande 21185 A., the dark bodies are eight times as massive as Jupiter. The third, Barnard's Star, has two satellites, each equivalent to Jupiter in mass. If these bodies are planets, they do not sound like suitable homes for intelligent life, but by interstellar standards Barnard's Star and Lalande 21185 A. are almost on our doorstep. It could mean that planets are a common phenomenon, to be found in millions throughout our Galaxy, including many of Earthlike composition.

Curiosity drove Man to explore the moon and survey Mars and Venus. An advanced civilization could have many reasons for sending life to the stars, reasons possibly so alien that we could not understand them. Whatever their motives, if their civilization has survived the thousands of millions of years which have elapsed since evolution began on Earth, it will be something completely unimaginable in human terms. To them, we may be only a forgotten experiment, the records of which have long been lost.



Any spacecraft from Earth which is destined to land on another planet must be rigorously sterilised before launching to avoid the possible spread of Earth organisms with unpredictable results. Even so, 100 per cent sterilisation cannot always be achieved, and although it is unlikely such organisms will survive a lunar environment, other planets, such as Venus, might already be playing host to some microscopic travellers from Earth, carried there by the Russian space probe (below) which landed in December, 1970.



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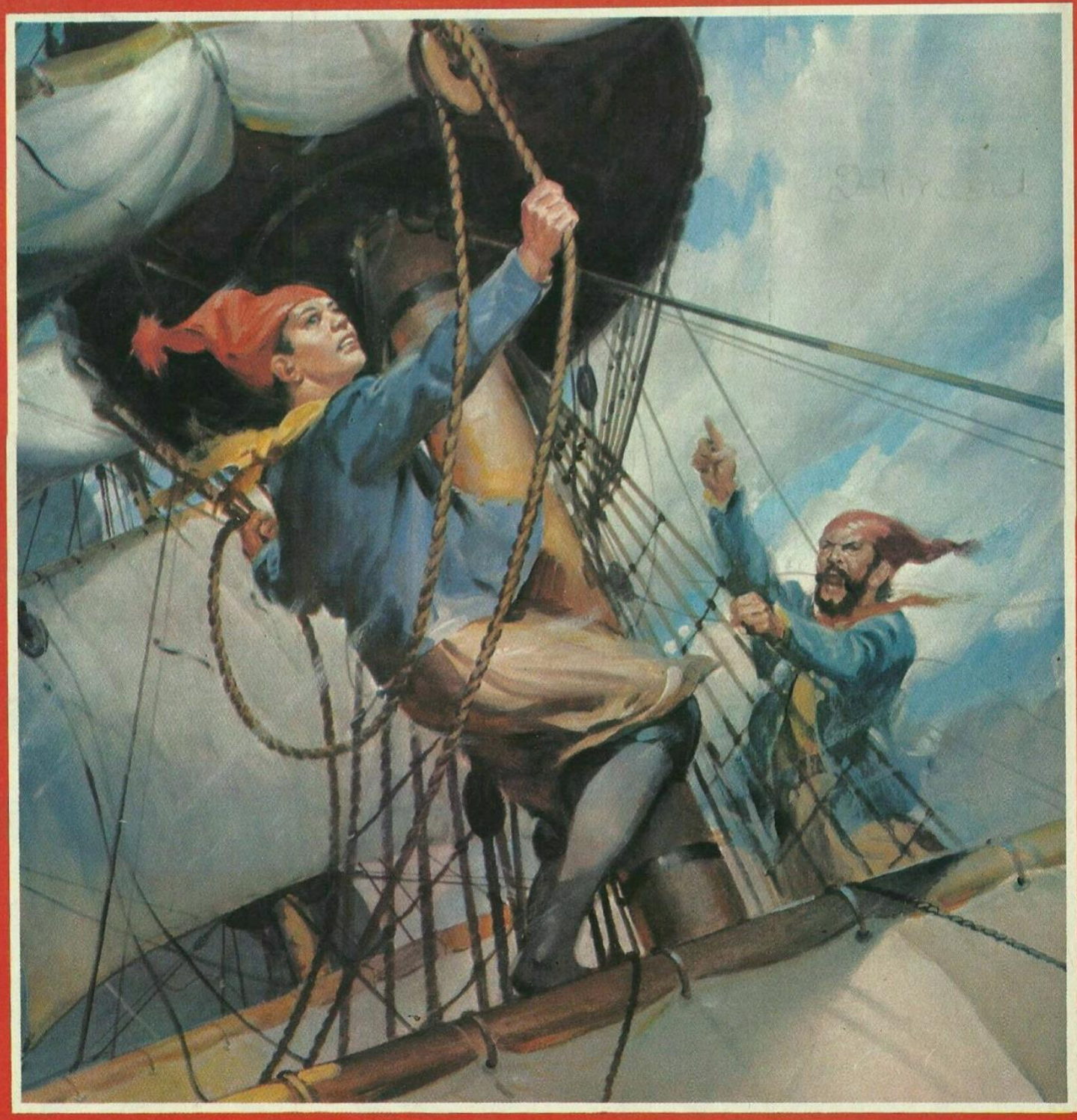

The Sailor Who Gave Away A Fortune

SEE INSIDE

A ship that can change jobs with the minimum of refitting has been designed for the American Navy to avoid the wasted expense of building conventional ships that soon become out-of-date.

THE QUICK-CHANGE SHIP

YOU can build a ship for a specific purpose, and whether it is a cruiser, an aircraft carrier or a destroyer, it remains so for the rest of its life, unless it undergoes an expensive refit.

To overcome this costly problem, an American designer, Dr. T. G. Lang, has devised a vessel with twin-hulls, like the one in our picture above.

Upon the hulls is placed a platform which, in our picture, makes the vessel into an aircraft carrier.

But other platforms can be fixed upon twin-hulls to become missile launching pads, floating hospitals, helicopter carriers or vessels used for many other purposes.

The one in our picture is being tested by the American Navy as an aircraft carrier. But the American marines think that such a platform would also be useful for amphibious assault landings and as a troop carrier.

Vertical and short take-off and landing aircraft are using the vessel in the naval experiments. The platform is attached to the hulls by four vertical struts and the total weight is 190 tons.

It has a top speed of 25 knots, a range of 450 nautical miles and it can carry a load of 25 tons.

Fuel for the twin gas-turbine engines is carried in three rubber bladders in compartments in each submerged hull. This weighs 18.9 tons. As the fuel is consumed, sea water is admitted to the hulls to serve as ballast.

The platform is well above the surface of the ocean, and control over roll, yaw and pitch is achieved with fin and canard control surfaces like those on an aircraft. These are attached to the hulls.

If the American tests are successful, the U.S. Navy may build a large number of these vessels in the 3,000 to 5,000 ton class so that they can spread their forces over broader areas of sea and, they say, reduce the threat of a nuclear attack.

Spaces of a standard size are built into the vessels. Into these can be put prefabricated engineering workshops, spare parts stores and so on. But if the vessel were to serve as a hospital, these could come out and be replaced by surgeries or an operating theatre.

PIGGY-BACK SKY RIDER

A vehicle that rides into space on the back of a rocket and skims back to Earth like a glider may be the space traveller's taxi of the future

TRAVELLERS to outer space in the future may ride in a glider that makes the trip, piggy-back fashion, on the back of a rocket. After its visit to a space laboratory, for instance, the vehicle, which is called a shuttle, could return to Earth, using its wings like a conventional glider.

It could, afterwards, make other trips into space, saving the cost of present craft, which can only be used once. Parts of the mother-rocket, it is hoped, will also be recoverable, saving costs still more.

To save weight, however, it is important for the shuttle to function as a glider. But because the designers do not want to build it with a motor, they have encountered problems in transporting the shuttle from the Kennedy Space Centre in Florida, U.S.A., to the site in California from which the United States Air Force will launch most of its shuttle missions.

One solution is for the shuttle to be towed by a cargo plane. Other ideas are that it should be carried on the plane's back, or slung beneath a specially made plane with two fuselages.

A plane being considered for the job of towing the shuttle is the Lockheed C-5A Galaxy, shown in the picture above. Only slight modifications to the C-5A would be needed for this, such as the installation of a towing hook on the towing plane and another in the nose of the shuttle.

The shuttle could also be carried on the back of the C-5A or nested in the underside in a partially-stowed position.

A modified Boeing 747 would also be able to carry or tow the shuttle. Another proposal is illustrated in the sketch below. This shows two Boeing 747 fuselages with the shuttle slung between them.

If a carrier or towing aircraft is developed, it might also be used for flight tests with the shuttle. The shuttle would be carried piggy-back or towed to a height of 40,000 or 50,000 feet and released for a long gliding flight. This would be like the final portion of the shuttle's flight back to Earth from a trip to outer space.

Horizontal flight tests would follow as part of a number of other experiments to see how well the shuttle could be handled.

If all these experiments are successful, the shuttle may soon be taking off.

VOICES ACROSS THE SEA

NOTHING could seem more isolated than an oil or gas rig two hundred miles from shore amid the raging North Sea. Yet, when a project by the Post Office has been completed, a man on one of these weather-swept out-posts will be able to make a phone call to anywhere in the world, or to send a telex message to wherever he wishes.

This will be made possible by a communications installation to be set up by the Post Office which will use radio waves to carry messages to and from the oil and gas rigs.

These will be transmitted from two new radio stations to be built at Scousburgh in the Shetlands and, probably, Mormond Hill, thirty miles north of Aberdeen in Scotland.

Men on oil rigs will be able to talk to anybody with a telephone anywhere in the world when a radio link has been completed by the Post Office

Huge 40-ft. dish aerials (as shown in our picture below) will point the radio waves at the troposphere, which is the lowest region of the atmosphere and is about seven miles above the Earth.

When they reach this region, the radio waves will be reflected back like a scattered shower (see bottom picture) so that those which return to the Earth will be very weak.

Nevertheless, they will still provide a signal which will be strong enough to be amplified by receiving stations on the oil rigs.

Two rigs have been selected to receive the signals, one for each of the shore transmitters. They will re-transmit calls destined for other rigs by a method known as line-of-sight transmission.

This uses microwaves which travel like a searchlight beam between stations which are within sight of each other for a distance of about 25 miles.

Each of the two oil rigs which will receive the transmissions from the Post Office's shore stations will do so with a 25-ft. diameter dish aerial, and will use smaller dish aerials to link other rigs with the system.

This installation will enable conversations to be held between people on the oil rigs and their colleagues in offices on shore wherever they may be.

Up to 72 one-way telephone channels will be available in each direction at any one time, this being the amount which each radio beam will carry.

For the technically minded, these radio relay links will operate in the 2GHz band and transmissions will be concentrated in 1 degree beams. The bandwidth is 1.5 MHz and mainland and offshore transmitter output stages will each have a power of 1 kW.

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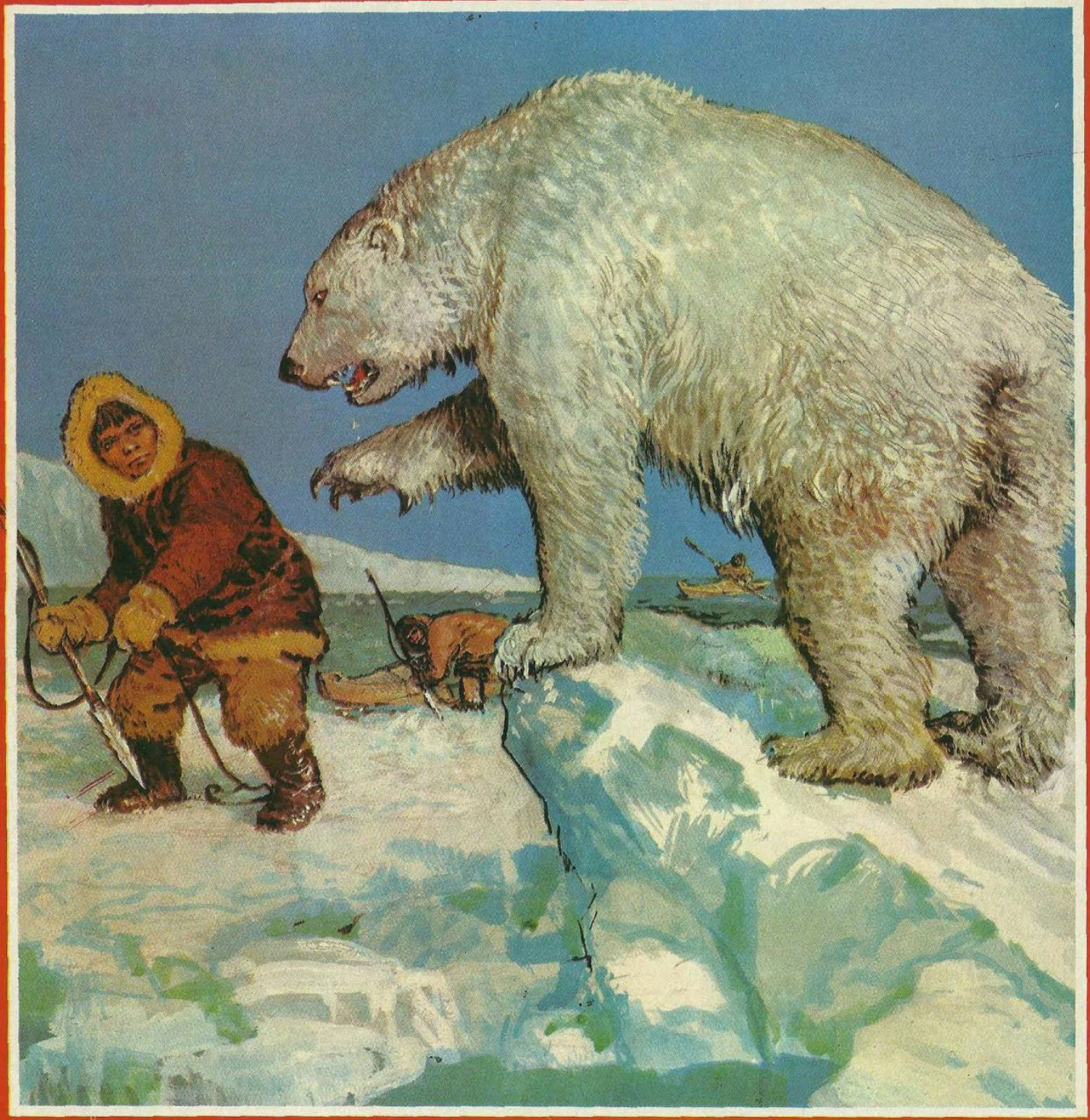
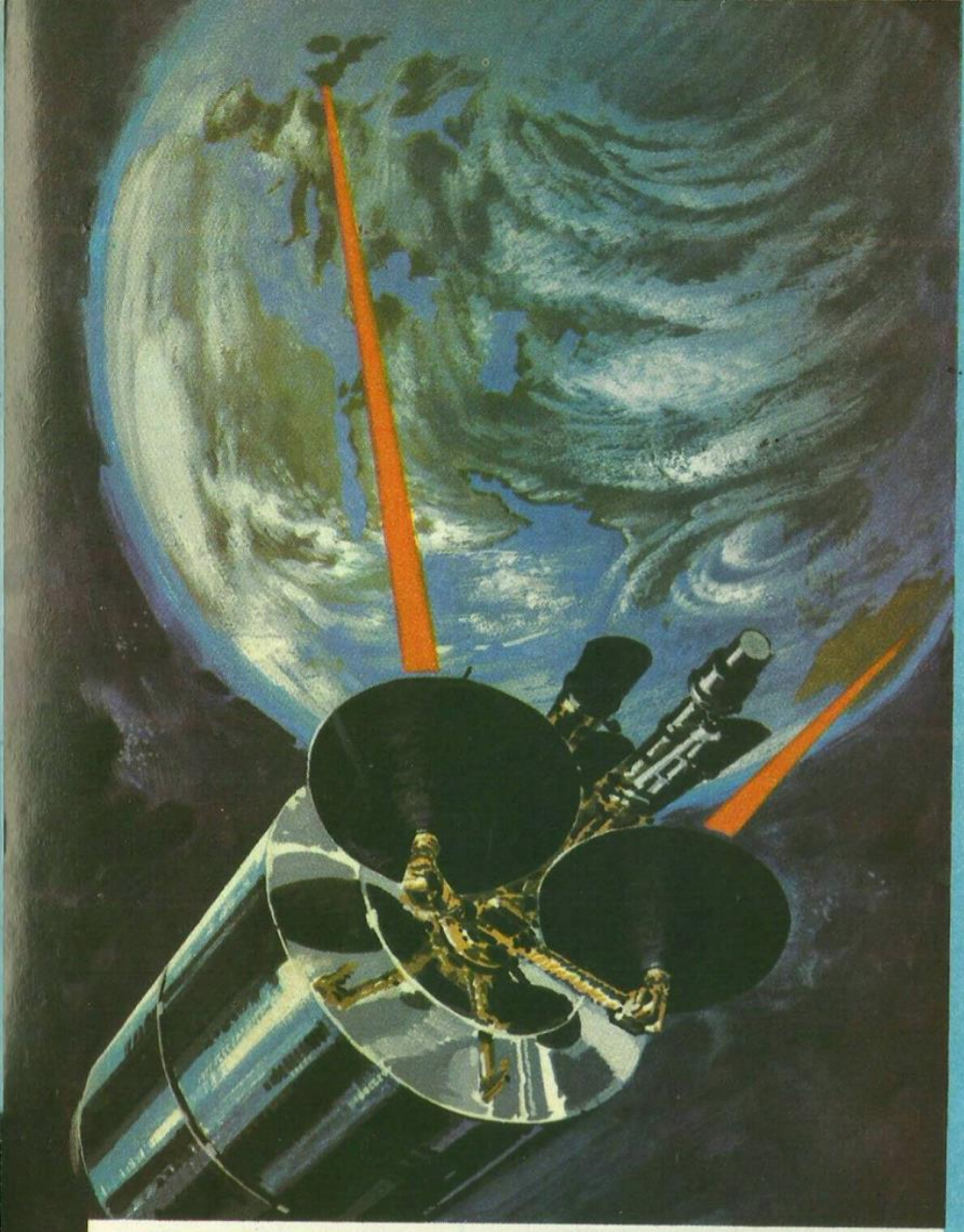
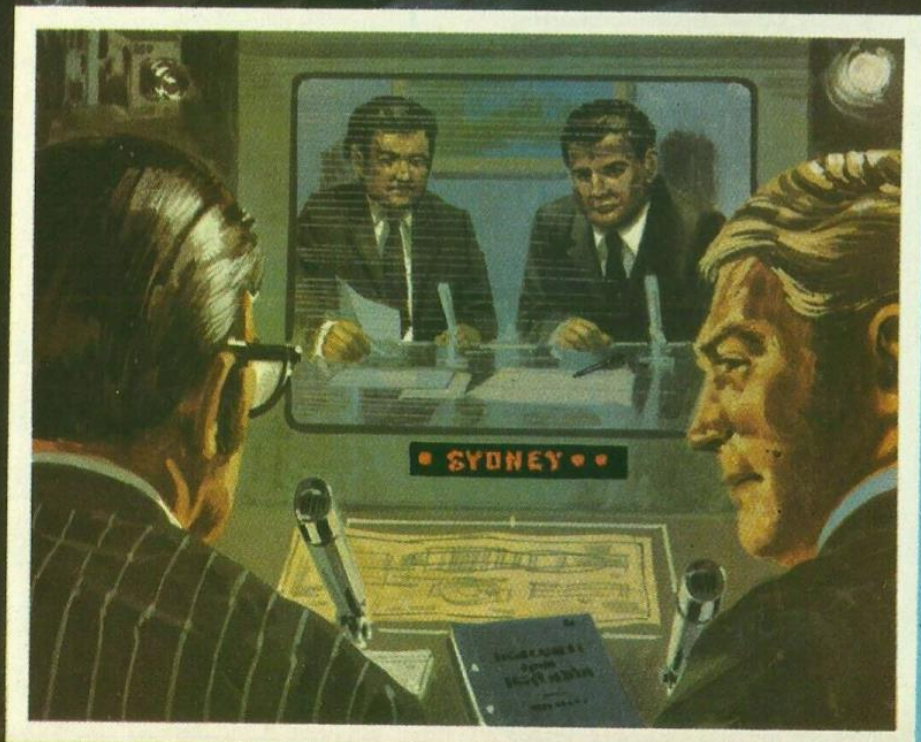


HUNTERS OF THE FROZEN WASTES

SEE BACK PAGE





SCIENCE SURVEY

FACE-TO-FACE-BUT A WORLD APART

EXECUTIVES who jet around the world for face-to-face meetings with colleagues overseas may soon be spared their exciting, if exhausting, globe trotting.

Before long, they will be able to go into a studio in one of Britain's larger cities and talk to a business friend thousands of miles away by television.

The man in Britain will see his overseas colleague on a TV screen — and be similarly seen himself — and the pair will be able to talk together as freely as if they were together in one room.

Already, the British Post Office is running a service of this nature on an experimental basis from studio centres in London, Bristol, Birmingham, Manchester and Glasgow.

The first of these link-ups was made last November when British Post Office officials in London held a conference with their Australian counterparts in Sydney, Australia. At the bottom of the page on the left you can see a similar conference in progress.

At the heart of the link between Britain and Australia was a satellite over the Indian ocean named Intelsat IV. It carried sound and vision from the British station at Goonhilly in Cornwall to an Australian station at Ceduna in South Australia. Land links in Britain and Australia were made by microwaves. These are radio waves transmitted in a narrow beam, like a searchlight's.

Intelsat, shown on the left at the top, is in an orbit which enables signals from the stations at Goonhilly and Ceduna to be beamed directly towards it. Upon receiving the signals, the satellite simultaneously boosts them and re-broadcasts them so that they can be picked up by the station for which they are intended.

Although this means that they travel along a 50,000 mile path between Britain and Australia, instead of the 10,000 miles which they would take if they followed the curvature of the Earth, the quality of reception is as good as that seen on a satellite link-up on your home TV. When you see astronauts splashing down in the Pacific after a flight to the Moon, the pictures are brought to you in this way.

In fact, the channels and associated land relays were set up as if for a TV programme hook-up which, to all intents and purposes, reduced 50,000 miles to the width of a conference table.

Unmanned, radar-controlled flying fire-fighters would take only seconds to reach the blazing cars in a race course pile-up.

THE FLYING FIRE-FIGHTERS

BILLOWING smoke, turned crimson by the light of the flames beneath it, can enshroud a crash on or near an airfield, or a pile-up on a racing circuit.

In these mercifully rare disasters, the need is to put the fire out, not in minutes but in seconds if possible, by swamping the flames with a blanket of chemical foam to starve the fire of oxygen.

Cold statistics show that most civil air crashes occur within six miles of an airfield and that fire breaks out within two minutes of impact.

The VFW-Fokker Company is developing a midget drone fire-fighter which may be the answer to fighting a fire with lightning speed where human crash crews are delayed by distance or obstacles.

The drones would be mounted in batteries of up to twelve, ready for action. Immediately a fire alarm was given, they would be launched in sequence, guided towards the fire by radar. They would home-in on the fire automatically and release a cargo of foam or other chemical liquid on to the flames.

Once their task was complete, the drones would return to their base and land on parachutes, so that they could be recovered and used again.

Fires which occur on airports, however, are adequately extinguished by the airport's fire brigade which is trained to reach and put out a blazing plane within five minutes of the outbreak occurring.

But for outbreaks which occur in places beyond the reach of airport fire brigades, the drone fire-fighters should prove to be second-to-none.

SCIENCE SURVEY Continued

THE SPY ON A STRING

A SECRET weapon — a helicopter on a cable that can carry radar and television to spy out the whereabouts of an enemy — may be used by armies of the future.

Already, it has been proved successful after trials in Germany, where it is being made. It could be extremely useful for "seeing" over the horizon for great distances when all radio and radar transmissions are being jammed by the enemy army.

In operation, the helicopter would be taken on its parent lorry to a place where the lorry is hidden from enemy planes among clumps of trees.

Then, from its back, would rise the helicopter carrying devices for sensing the enemy's position. These could include radar or infra-red equipment which detects objects by the heat they radiate or equipment which intensifies any available light and enables a TV camera to create a detectable picture.

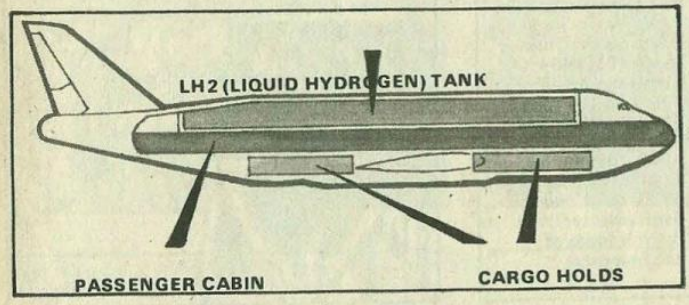
No matter how high the helicopter rises — and it will be able to attain a height of several hundred yards — it will remain connected to its cable through which will be carried all the information it gathers. This avoids the use of radio transmissions which could be detected by an enemy, giving away the position of the helicopter, or jammed.

Through this cable, the helicopter is provided with fuel, signals which operate it (for it does not contain a pilot), electrical power and height control.

So far, the helicopter has only been tested on a lorry, but a similar one could be carried by a ship. Another version is being developed for military use which could stay aloft for over 24 hours.

It has been designed to land safely if its cable breaks. One which did so made a good landing into a back garden, hurting nobody.

A JUMBO FULL OF GAS



AT first sight, the Boeing 747 (above) looks like any other jumbo jet. But this type, if built, would be very different indeed. Instead of burning paraffin, it would feed its engines on liquid hydrogen gas. As shown in the diagram on the left, the familiar hump behind the cockpit would be extended right back and would contain a huge gas tank.

Such a plane would have only three-quarters of the take-off weight of a conventional 747, helped by its much lighter fuel.

THE DUAL-FUELLED SHIP

OIL and nuclear fuel are the unlikely partners in the propulsion system of a monster tanker which has been designed in America.

It is a compromise that meets the objections of those who feel that a ship powered wholly by nuclear means is unreliable and the source of dangerous pollution.

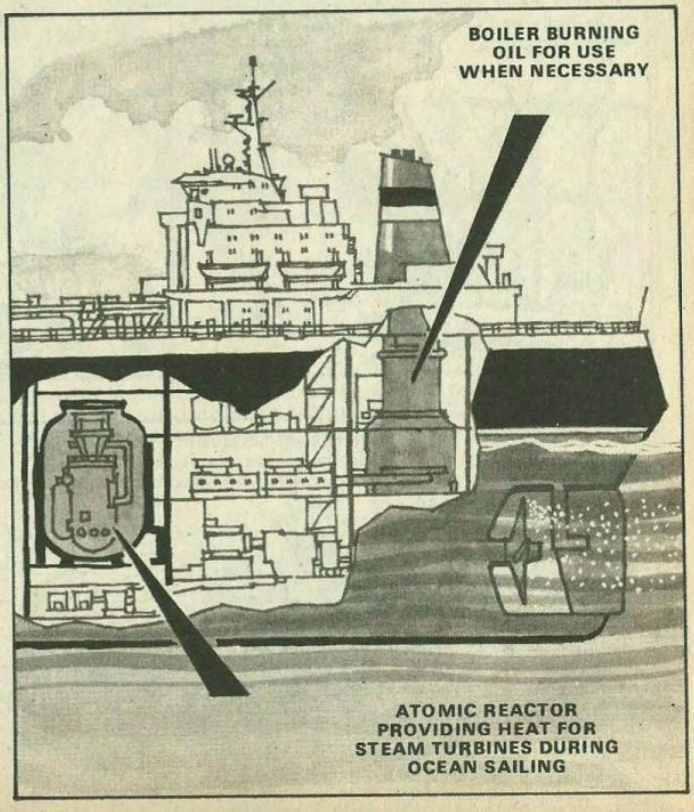
To meet such complaints, the designers propose that their ship should use oil when entering or leaving port and then switch to atomic power when on the high seas.

Each ship would be designed to carry an atomic steam generating system as well as a conventionally fuelled steam unit, so that the captain could use either system or both in his ship of 414,000 tons.

The captain would then have a ship ready to sail on oil if there were delays in getting the reactor working, or on nuclear fuel if there was a shortage of oil.

The design has been proposed by an American firm which wants financial support from the U.S. Government for the building of 12 ships that would use these two systems.

However, there is some doubt in America as to whether such ships would be feasible. A firm that builds nuclear reactors for civilian use are wary of the idea but have said that they will study it. And the U.S. Government, which has received many requests for ship building subsidies, may not have enough money to spare to back this unorthodox design



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No. 636 23rd MARCH 1974
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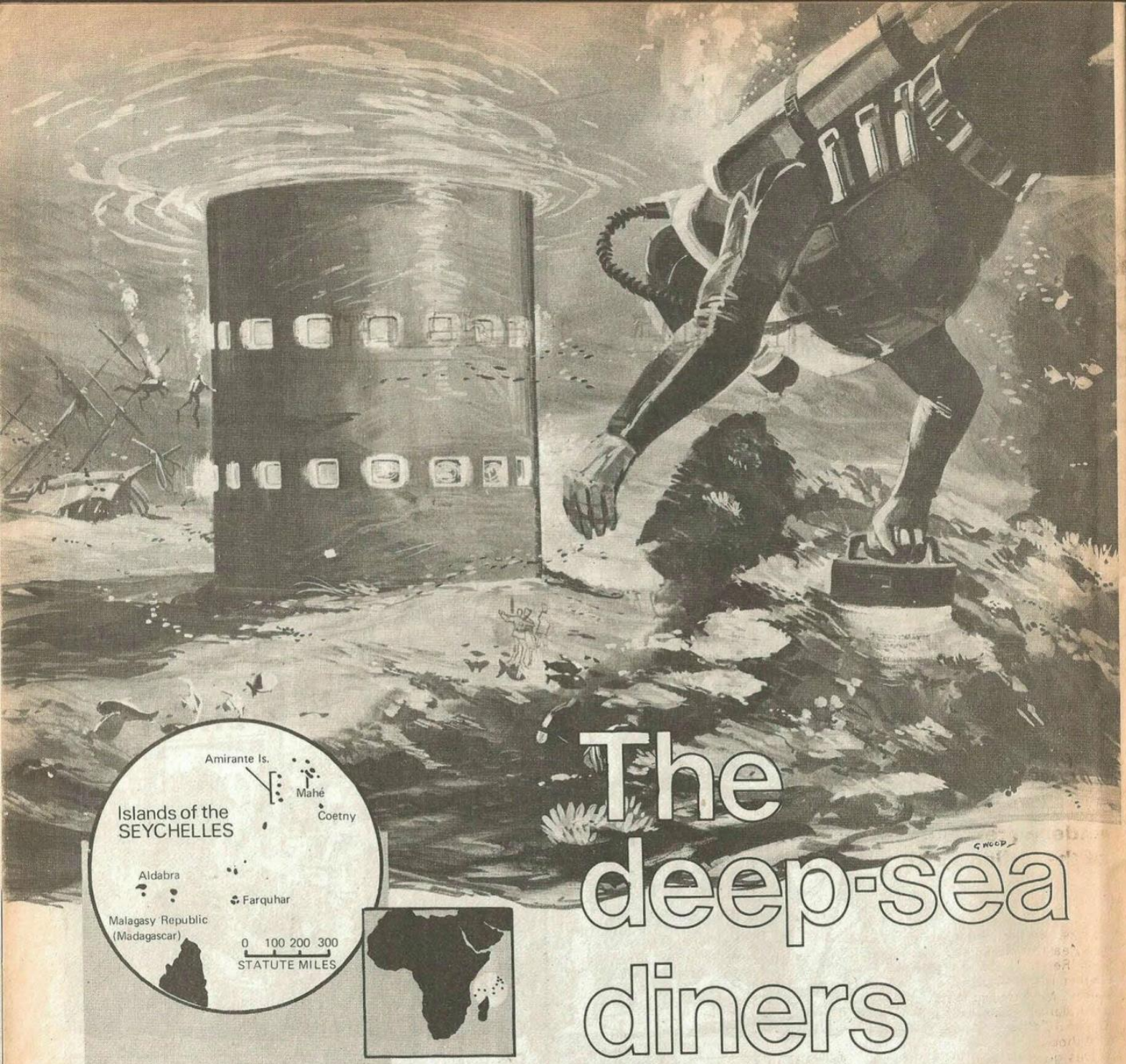
The Valley of Death

Six hundred men inspired an immortal poem by Lord Tennyson. See inside.



The deep-sea diners

Bird-watchers have led the field in the observation of wild life. But they will have unexpected rivals when fish-watching from an underwater restaurant (top picture) becomes possible. Their observation post will be a partly-submerged restaurant resting on a bed of concrete near Mahé, one of the Seychelles Islands (see map above). Sitting in air-conditioned comfort, diners will be able to see divers, a submerged wreck (put there as a tourist attraction) and a wealth of natural coral. Called an Oceanarium, this restaurant will have two storeys below the sea, one at sea level and two above it.

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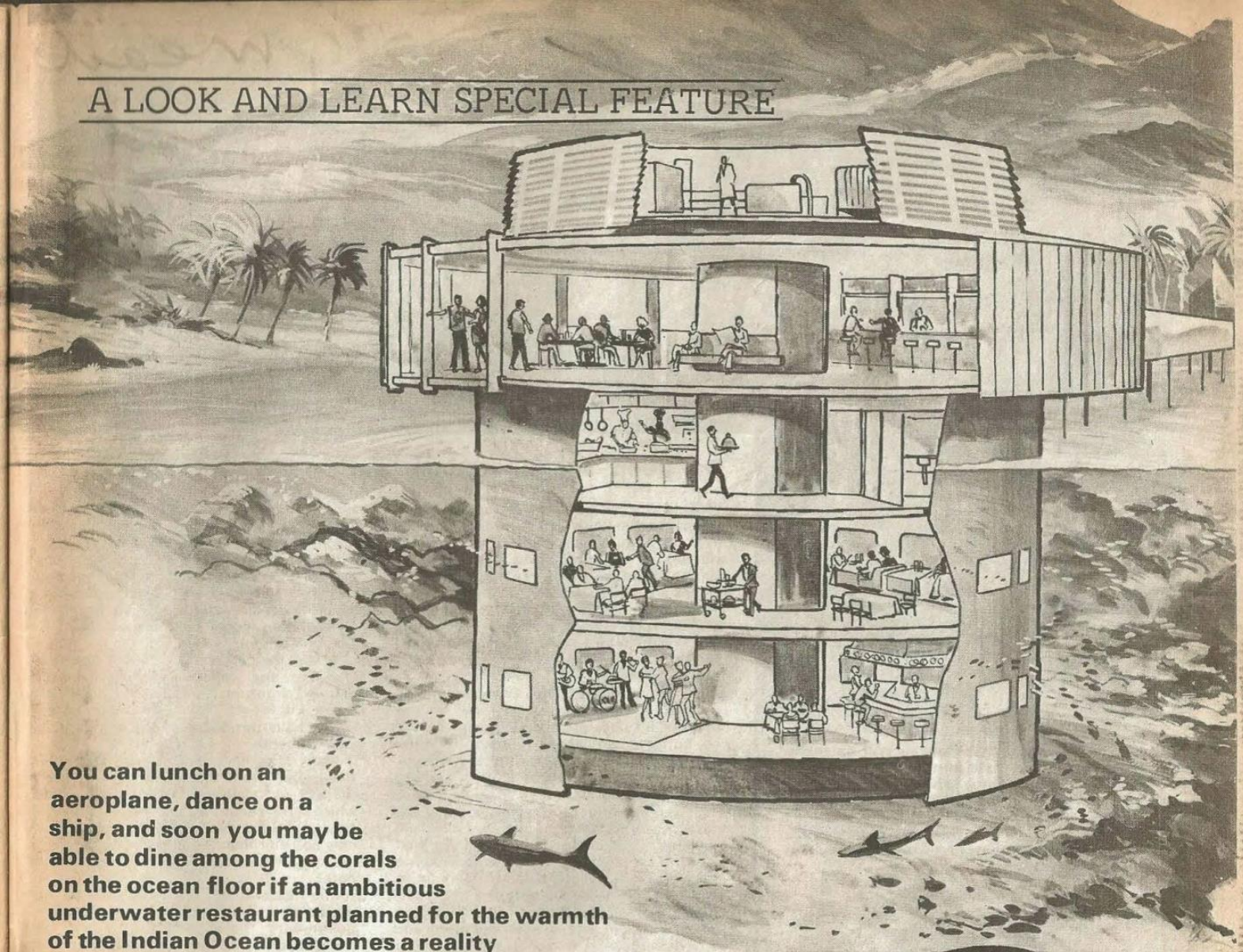

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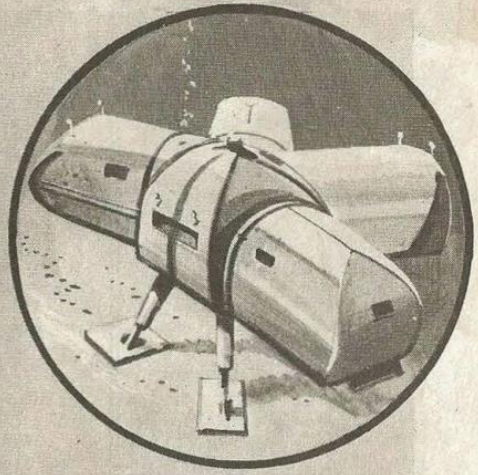

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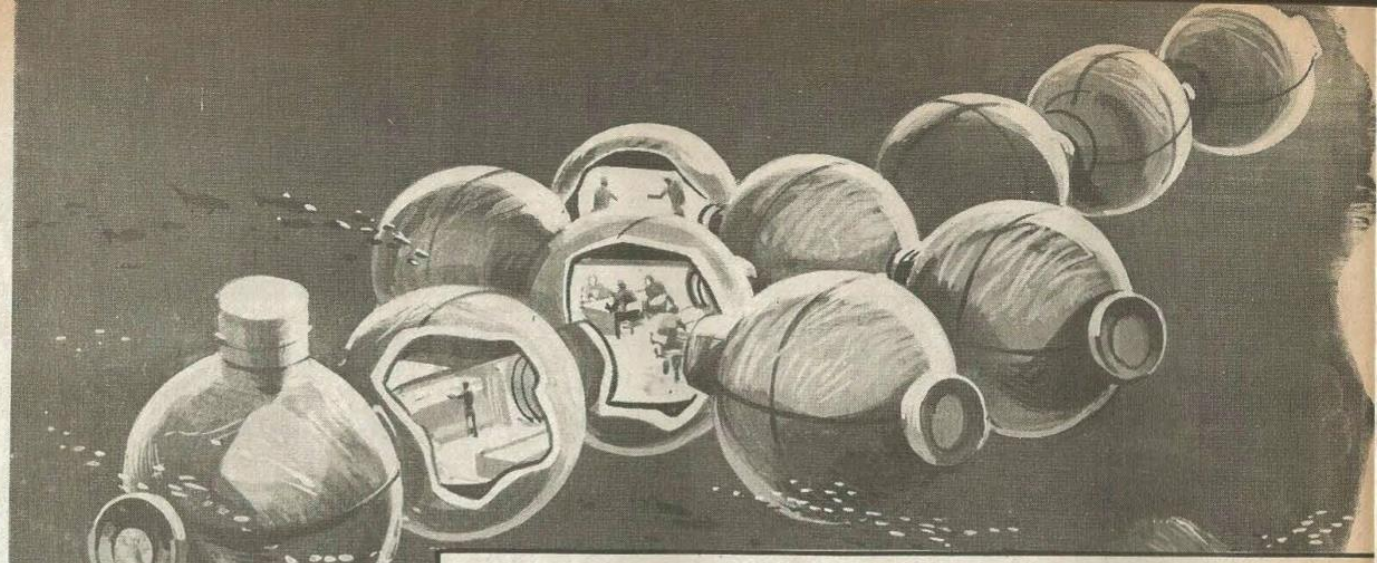

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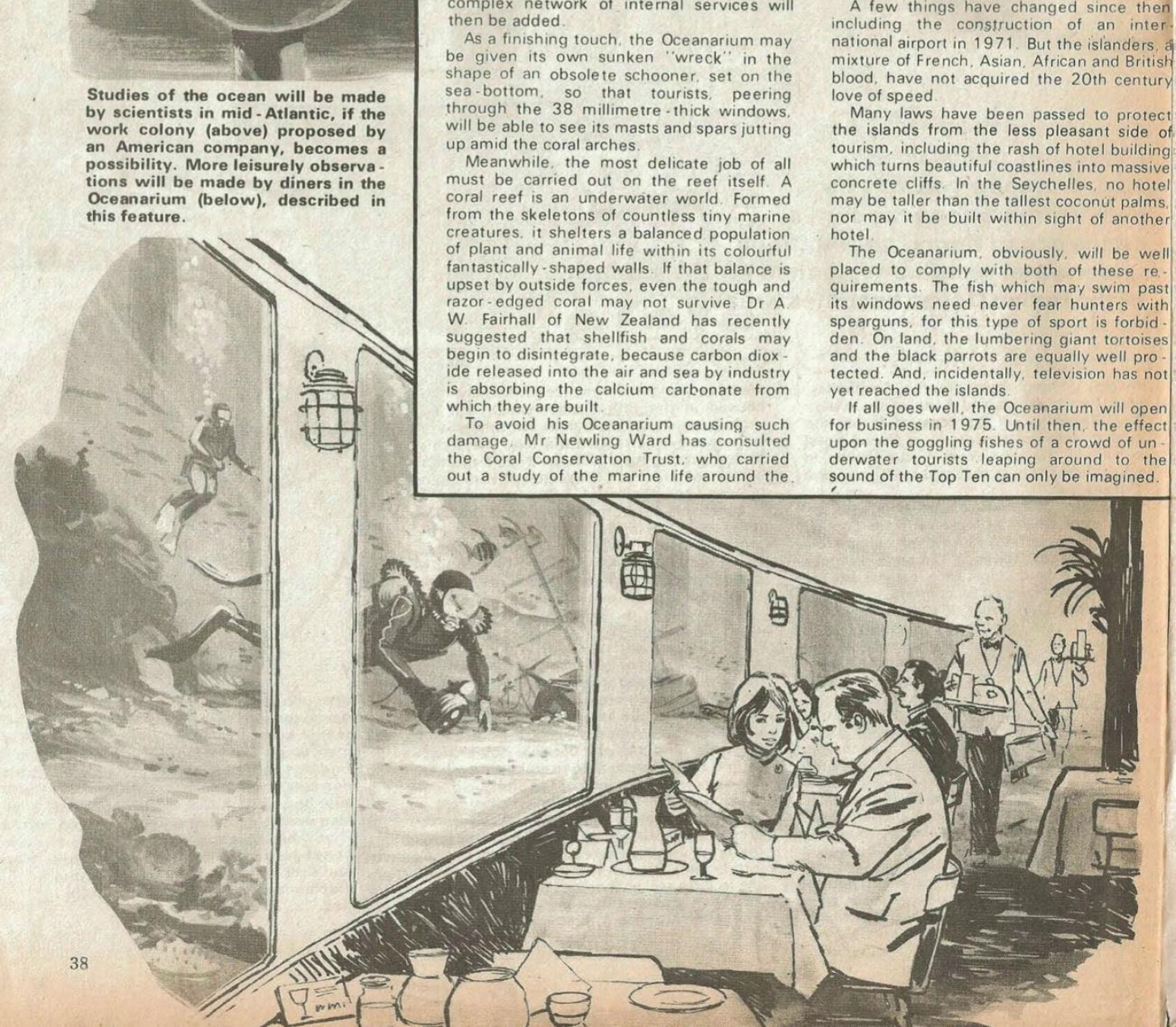

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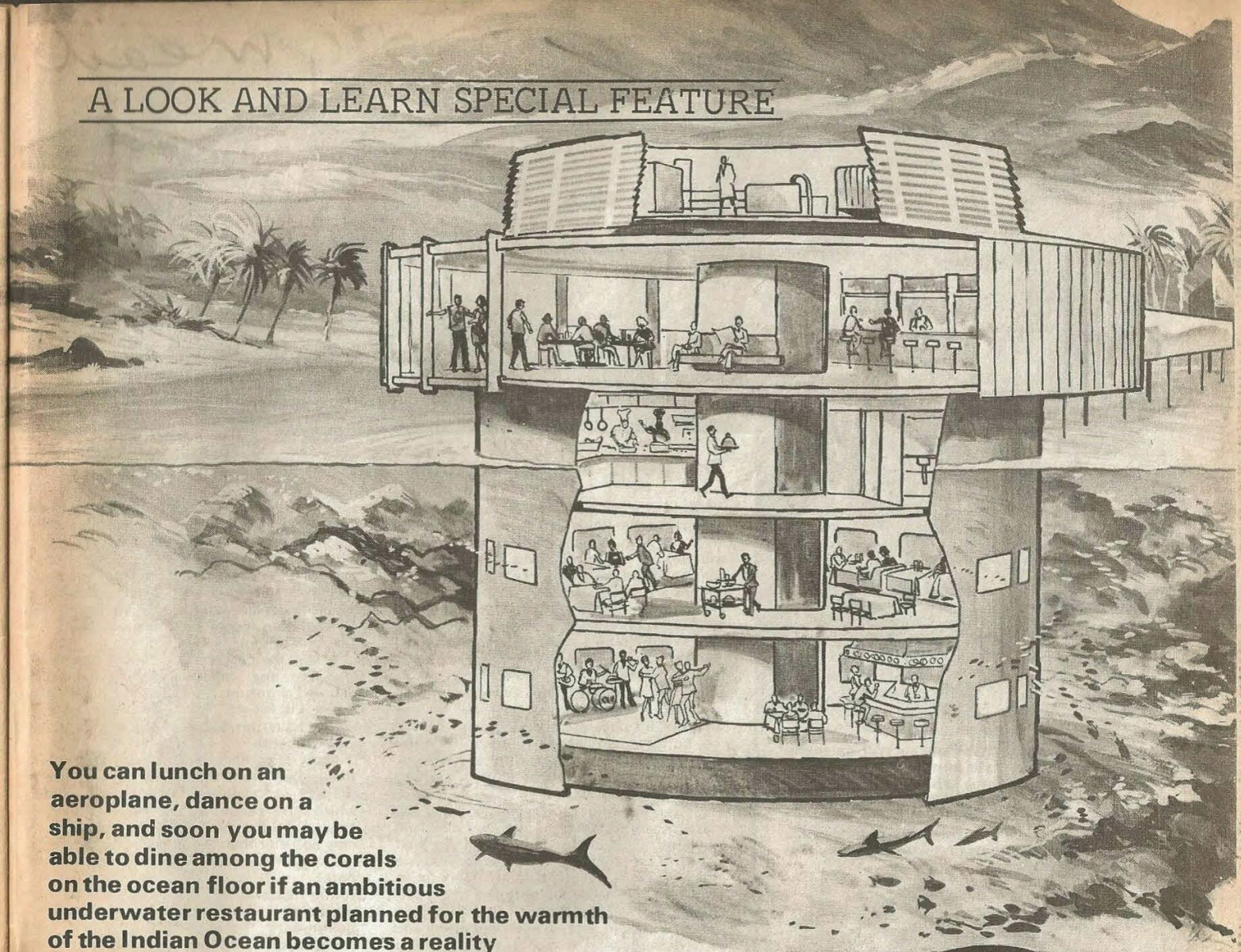

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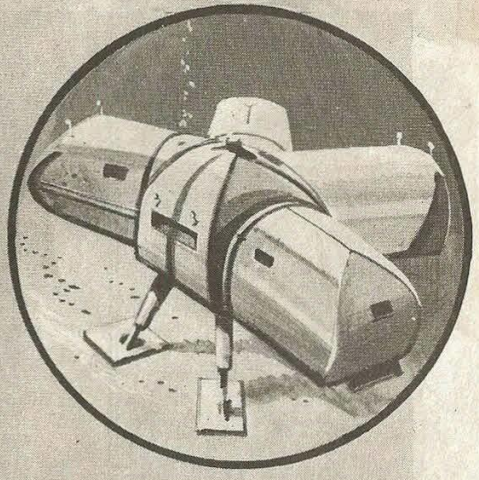

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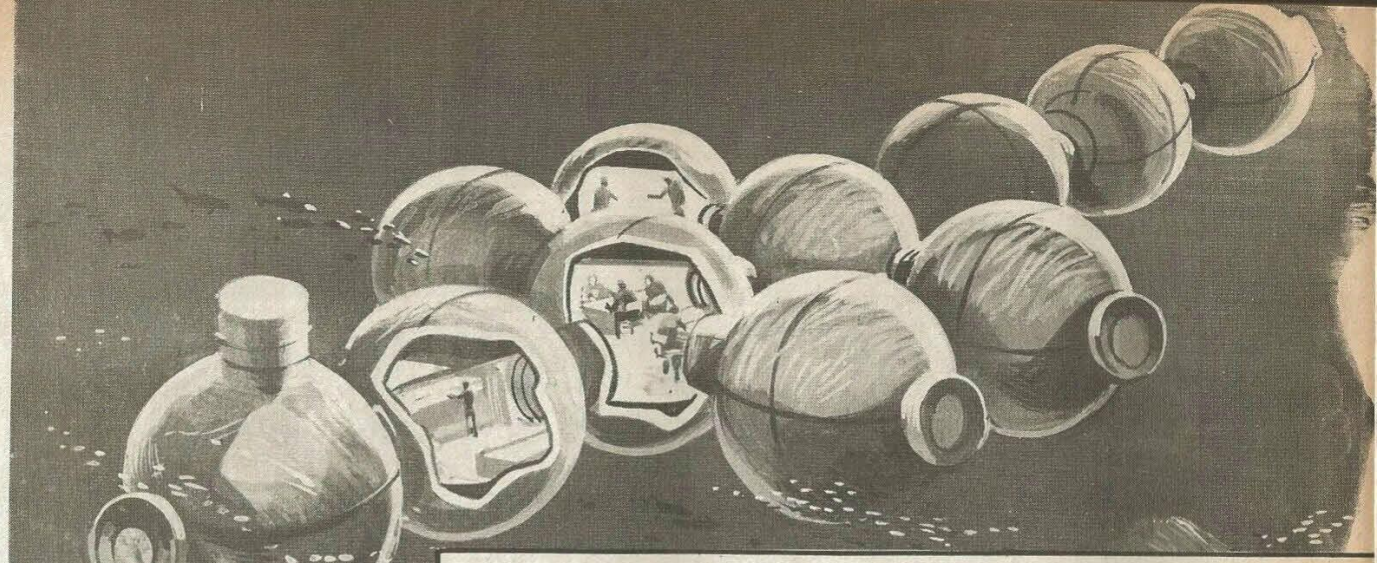

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No. 637 30th MARCH, 1974
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'The Dark Satanic Mills'

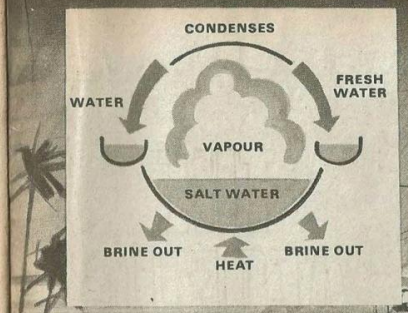
See inside

SCIENCE SURVEY

THE ATOMIC-POWERED ICEBERGS

To keep the world's taps flowing with fresh water, two scientists want to bring icebergs from the Antarctic to the deserts — by atomic power

Like a string of gigantic barges, the icebergs would be linked in a line at least twelve miles long and towed to areas where water was needed.



Using a plant like this, Israel converts 10,000 gallons of sea water to fresh water each day. The inset diagram shows how salt water is heated to give off water vapour. This condenses as fresh water into channels beside the salt water flow.

TODAY, when you turn on the tap, what comes out of it depends on where you live. In June 1973, in Duluth, Minnesota, it was asbestos fibres. In Miami, in the same year, it was typhoid bacteria. In Britain it may be a chemical which, someone tells us, will improve our teeth, whether we want to improve them or not.

All of these foreign bodies, of course, are mixed in with the drinking water. Some of them are unpleasant, and the second one could be fatal. But what is even more unpleasant, and certainly fatal, is to turn on the tap and receive nothing at all. For days, months, or even years. And this is happening over large areas of the world, areas which are increasing.

As any good atlas will show much of the surface of our planet is desert. From the Gobi in China, the dry lands run through the heart of Asia to link up with the sands of Arabia and the Sahara. Their spread is enormous. The Sahara, alone, could swallow the whole of Europe.

Down the western edge of North and South America, the deserts stretch, paralleling the great mountain chains of the Sierra Nevada, the Sierra Madre and the Cordilleras.

Inhabited Australia is little more than a built-up coastline surrounding the wastelands of the interior. Once, many of these deserts were fertile fields or forests. Inefficient agricultural methods helped to reduce them to dry desolation. We desperately need to restore their fertility to feed the world's growing population. Whatever new methods we use to do this, there is one basic necessity which must be provided before they will work. That necessity is water.

With almost three-quarters of the world covered to an average depth of 12,000 feet by the oceans, a water shortage seems improbable. The problem is that we cannot drink salt water if we wish to stay alive. We gave up that ability when our finny ancestors flopped ashore to stay.

Industry and agriculture, too, need fresh water, although not necessarily of the same degree of purity as that required for drinking. Desalination, the removal of the salt, is the most obvious solution. It is being carried out on a comparatively small scale at present, but the expense involved may raise the price of fresh water considerably if it becomes a major source of supply.

Israel, a small country containing much desert land, has made some of the biggest advances in this field in recent years. At Haifa, on her northern coast, a desalination plant which converts 10,000 gallons of sea water per day began production in 1973. Here, salt water is heated until it gives off vapour, which rises, leaving behind the salt and other heavy substances.

This hot salt water flows beside a stream of cold, purified water which causes the vapour to cool and condense. As it condenses, it falls into the cold stream.

So efficient is the Haifa plant that it may cut the cost of "manufactured" fresh water by one-quarter. Even so, it will still be more costly than fresh water drawn from orthodox sources.

In addition to desalination, however, Israeli and American experiments in the Negev Desert have shown that crops can be grown in ground irrigated with salt water. Encouraging as this is, it is still limited by the type of crop, the degree of salinity of the water, and the nature of the ground, for there are many kinds of desert. Some greater, more direct source of fresh water is needed to avert a world-wide drought.

J. L. Hult and N. C. Ostrander of the Rand Corporation, the famous Californian research centre, have planned how to trap such a source. It is the Antarctic. For twenty million years, snow and ice

CONTINUED ON NEXT PAGE

Controlled from a unit like this (above), nuclear power would propel the icebergs to areas where water was needed. But they would have to moor well out from the shore because of their enormous draught (right).

SCIENCE SURVEY Continued

have accumulated on the mountains and plains of this continent at the South Pole.

Now, except for a few peaks and coastal areas, the rock surface is buried beneath an ice-cap varying from one to two *miles* in thickness. This vast mass is frozen fresh water. Locked in the Antarctic's icy grip is three-quarters of the world's total supply of this vital fluid. Hult and Ostrander are not the first men to think of tapping the ice-cap, but they may be the first such men to see their plans carried through, for they live in the age of nuclear power.

Spreading under the pressure of its own enormous weight, the ice pushes out beyond the underlying rock of the continent, into the sea. Because water expands when it freezes, any mass of ice is lighter than an equivalent volume of water, and therefore it floats.

Floating Antarctic ice tends to break up into conveniently rectangular 'bergs, well suited to the needs of the Rand project. Every year, enough of these icebergs are formed to meet the present water requirements of our civilisation several times over.

And this yearly output is a tiny fraction of the total volume of the ice-cap. The supply, then, should last for some time, unless the removal of the icebergs has some unforseen effect upon the polar climate, causing it to produce disastrous results.

* * * *

Under the terms of the 1959 Antarctic Treaty, which protects the White Continent from the kind of reckless exploitation which ruined many other new territories, this possibility may become an obstacle to the Rand plan. Meanwhile, the methods of transporting the icebergs are being worked out in detail.

Like a string of gigantic barges, the 'bergs would be linked in a line not less than twelve miles long.

This has been calculated to be the minimum length for efficiency — the maximum could be as much as fifty miles. Individual 'bergs would be less than a mile in length, approximately two thousand feet wide, and a thousand feet in depth, although most of their bulk would be submerged.

It is easy to appreciate why Hult and Ostrander are considering the use of nuclear power to move such an unwieldy fleet. Propellor units fitted to each 'berg would be connected to a power plant aboard a suitable ship.

The idea is not entirely new. During World War Two, a scheme code-named "Habbakum" proposed the use of icebergs as giant aircraft-carriers.

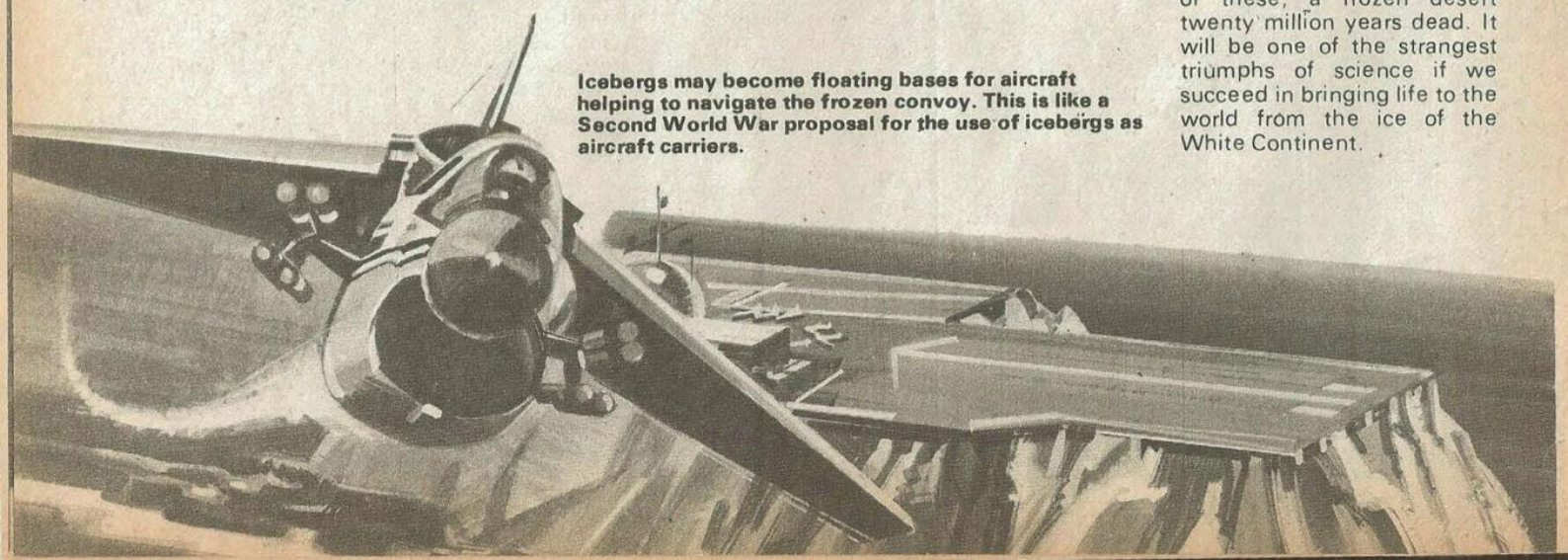
What would be entirely new is the experience of captaining such a craft. No seaman, however wide his knowledge of ships, has ever steered anything remotely comparable to this chunk of mobile geography. If a fifty-mile berg train entered the Thames, the leading end would reach London's dockland just as the rear end was leaving the North Sea!

Voyages may take twelve months or more, and even at the modest speeds involved, the 'berg trains would be difficult to stop. Their ponderous mass, beside which the largest warship or tanker would shrink to toy-like proportions, would need days in which to halt or turn. Radio, radar, helicopter patrols and all the resources of modern navigational aids would be required to guide them safely through busy shipping lanes, particularly in darkness or fog.

Plastic wrappings would insulate the ice from the worst effects of rising temperatures during the long journeys north to warmer waters. At their destination, their draught of almost nine hundred feet would force them to anchor well out from the shore, forming an icy breakwater which may affect the ebb and flow of the tide.

Formidable though these difficulties are, they are small when compared to the consequences of drought. In Western India, people, crops and cattle die as rivers shrink and disappear into the dry, crumbling earth. In Africa, the Sahara creeps steadily south, burying thousands of square miles of land every year. The central plateau of Antarctica is a desert fiercer and more terrible than either of these, a frozen desert twenty million years dead. It will be one of the strangest triumphs of science if we succeed in bringing life to the world from the ice of the White Continent.

Icebergs may become floating bases for aircraft helping to navigate the frozen convoy. This is like a Second World War proposal for the use of icebergs as aircraft carriers.



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No. 639, 13th APRIL, 1974.
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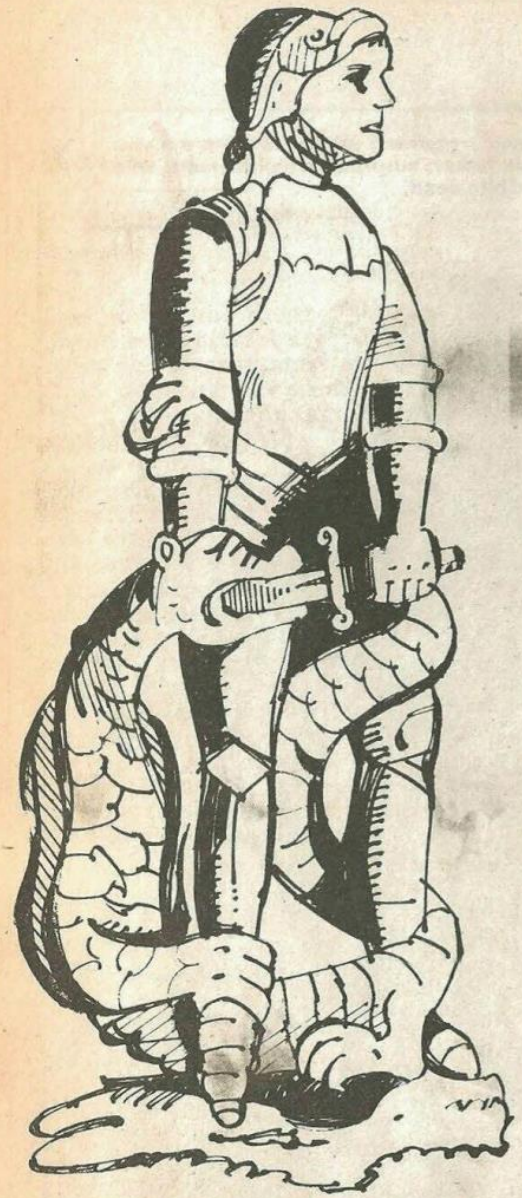
MORE THAN MYTH ?

The Great Worms From The Deep



Above, a sketch of Sir John Lambton, slaying the "Lambton Worm." Full details in our article.

Charles Dickens once wrote: "Seasickness is like a belief in ghosts, everyone entertains some misgivings on the subject but few will acknowledge any." Similarly, most people believe or fear that monsters of the deep — sea serpents, krakens and so on — do exist. Like the many convinced observers of U.F.O.s, surely not *everybody* can be wrong?

THE huge thaw at the end of the Ice Age produced great lakes and rivers of fresh water. Some marine animals, such as salmon and eels, learned methods of moving from fresh to salt water. Others elected to remain in fresh water.

The cold lakes of ancient Britain were the homes of creatures called Orms which preyed on fish. The name is derived from the Scandinavian *Sjöorm* or sea-serpent. Medieval folk tales refer to "loathly worms, water horses and dragons." An early reference to a Scottish monster occurs in the "Life of St Columba" A.D. 700.

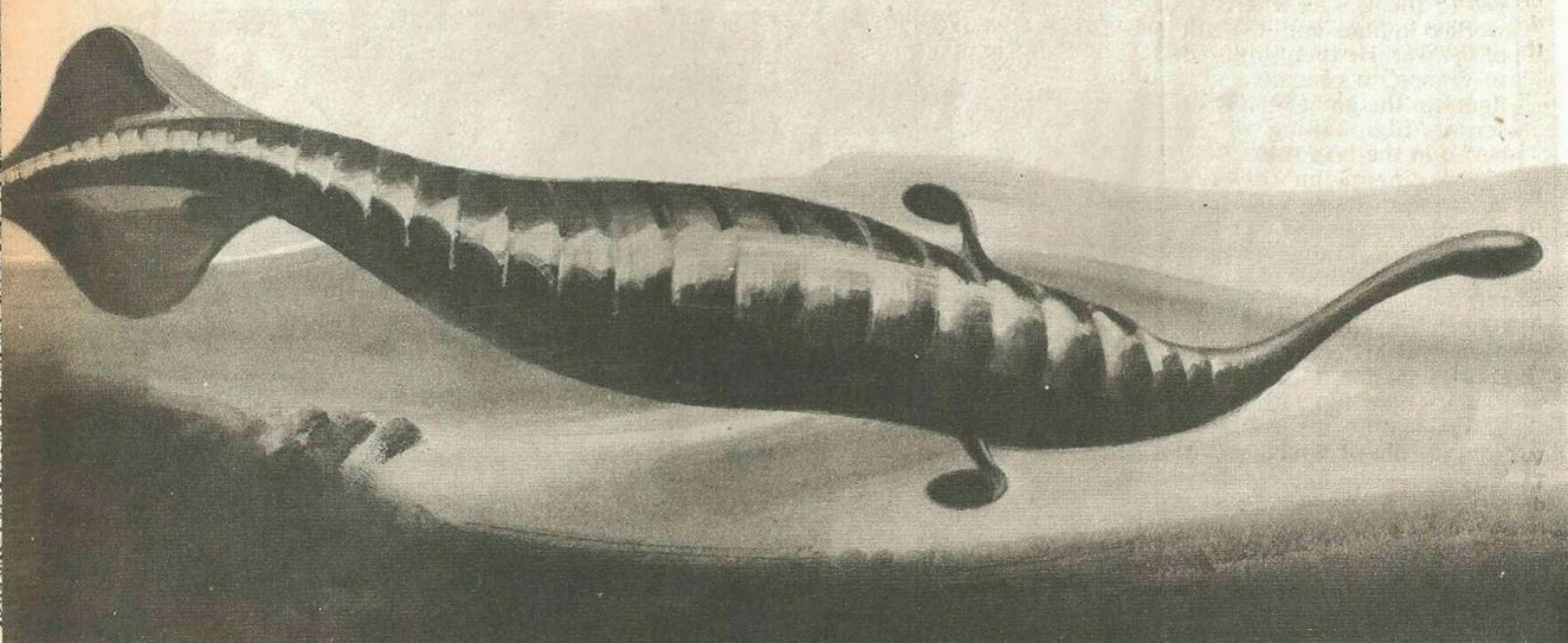
The Norsemen knew of salt water Orms and used their ugly features as figureheads on many of their ships. Norse leaders of great strength were called Orms, a tribute more to their physique than their looks! One such Norseman gave his title to Great Orme's Head on the North Wales coast and Worm's Head peninsula in South Wales seems clearly named for its resemblance to the Orm.

English folk lore has many stories of water monsters in the form of worms, all of which appear to have been slain by knights. One of these, Sir John Lambton, was fishing on the banks of the River Wear when he landed a worm "of most unseemly and disgusting appearance." Horrified, Sir John threw it into a nearby well.

* * * *

In the well, the worm grew very large and made its way back to the River Wear. It would come ashore and terrorise the countryside. Workers refused to till the fields and old Lord Lambton, Sir John's father, was living in the Hall in a state of siege.

Attempts to kill the monster were in vain as the creature seemed able to rejoin the parts of its body which had



been severed. On the advice of a friendly witch, Sir John studded his armour with spear heads and with his crusading sword, sallied forth to slay the worm.

As the monster enfolded the knight in its coils, the many spear blades covered it with wounds, making it weak from loss of blood until finally Sir John hacked it in two with his sword. The severed portion was washed away in the River Wear which was in flood. So perished the Lambton Worm and a statue still exists, depicting its slaying.

* * * *

There are many stories that are Scottish in origin. One called The Worm of Linton in Roxburgshire, was slain by the Laird and is remembered by a sculpture inserted in the porch of Linton parish church.

The Loch Ness monster has long been known to Highlanders. Legend seemed to become fact in the 1930 s when a strange shape was seen and photographed by two different witnesses. Experts soon dismissed the reports as nothing more than floating logs, otters swimming in single file or some other similar occurrence. There were many other sightings by witnesses who had no means of recording their experiences and without clear photographic evidence, experts naturally treated such reports with contempt.

In the opinion of some zoologists, from descriptions and sketches, the creature seemed to have the appearance of a *plesiosaurus,* a prehistoric animal resembling a turtle.

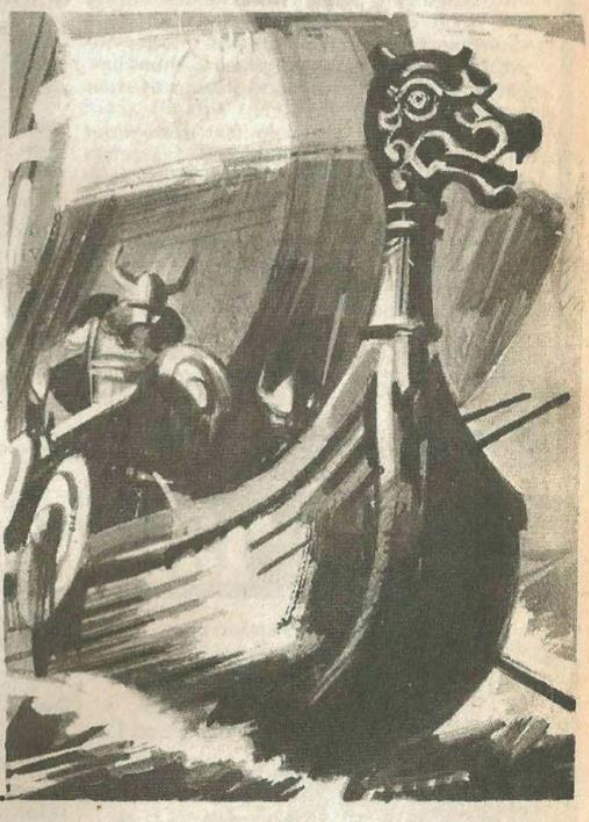
In 1958, Francis J. Tully discovered a fossil in America which, although small, resembled in appearance the descriptions given of the Loch Ness monster. This was called a *Tullimonstrum,* a segmented invertebrate with a slender, swan-like neck and a body like a *plesiosaurus.*

This looked as if it could establish a link between Tully's monster and the creature said to inhabit Loch Ness. It did prove that worm-like animals of the water had existed in the past.

* * * *

Take the *Coelacanth,* for instance. Scientists thought that this fish had been extinct for millions of years. Then in 1936, several specimens were caught off South Africa so the experts had hastily to revise their opinions and admit they were wrong. If this can happen with a comparatively small species, why should there not be a "Great Worm" in Loch Ness?

This was claimed to be no mirage, no line of floating logs, but a genuine sighting of "something unknown" in Loch Ness.



The Norsemen knew of the ancient legends of the "Orms" and used their fearsome features as figureheads to frighten their foes.

Worm's Head peninsula in South Wales. The shape is supposed to resemble the dread "Orm" from which the name is derived (right).

Left, the *Tullimonstrum,* believed by some people to be identical with the Loch Ness monster.

Action-Packed Fact and Fiction

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Where They Remember The Bounty

The first in a new series "Picture Profile." See Inside.

MORE THAN MYTH ?

Were the ancient pagan gods invented by primitive people to provide an explanation for the natural phenomena they could not understand, or did these gods exist as beings from another planet?

Did men from space visit earth?

FAR away in the universe — so far that the distance is unimaginable — may be a sun with a solar system and a planet on which there is life. On this planet there may be people very like ourselves at an early stage of evolution.

Nobody can prove or disprove this supposition, but we can at least admit that it is possible. Also, without stretching our credulity too far, we can accept that, in years to come, astronauts from Earth may land upon this distant, inhabited planet.

How would the space men from Earth appear to the primitive people on that distant planet, who may be at a stage of development comparable with our own Stone Age?

As they would have no common language by which to converse, and as the Stone Age men could have no possible conception of how their visitors had travelled or from where they had come, it would not be strange if they regarded the space men as more than natural creatures — as supernatural, in fact.

And when the space men had left, the Stone Age men might draw pictures on the walls of their caves depicting their mysterious visitors; and if the visitors left behind any scientific instruments, the Stone Age men might regard these objects with extreme awe.

As the years went by, the story might be handed down, from generation to generation, of the visit by the strange beings from far in the unknown. And imaginative stories might be told about them — how they were creatures with amazing powers. Things which the Stone Age men did not understand, like thunder and lightning, storms and fine weather, might be attributed to their feelings of anger or pleasure.

To be blessed with fine weather, perhaps one would have to appease these inhabitants of the skies with a sacrifice. Creatures with such powers as the superstitious Stone Age people might attribute to them were worthy of a name which describes a being that is above all others — a god, for instance.

Before the arrival of Christianity, people on Earth had many gods — gods that controlled the weather, gods that gave men strength in war, gods that protected seafarers, and so on.

It is generally believed that these were born in men's imaginations to explain things which they could not explain rationally at the time, like the streaks of fire in the sky we now recognise as lightning.

But could there be another explanation for our Earth gods? Did our planet receive a visit in the distant past from advanced beings from another planet, like the space men we imagined at the start of this article?

One man who believes that this is a theory worth considering is Erich Von Daniken, who set out his arguments in a book called "Chariots of the Gods?" (Souvenir Press Ltd.) In this he has amassed a great many facts to support his assertion. He mentions markings on the plain of Nazca in the Andes which he says look like an aircraft parking bay. There are other markings on the plain which archaeologists say are Inca roads, but which Mr. Daniken considers represents the layout of an *airfield*.

* * * *

There is more to support his beliefs in Northern Italy, where there are cave drawings of men in things that look like space suits with, on their heads, what could be helmets. They could equally well be dancers in costume. Mr. Daniken also sees a space man in an ancient drawing at Tassili in the Sahara (on the right of this page). You can decide for yourself whether you agree with him.

It is exciting to think that men from another planet came to Earth a long time ago. Space fiction writers have used it constantly as a theme.

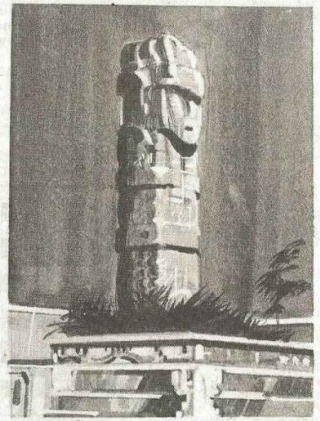
We have to admit that it is possible, because it is conceivable that there are people living on another planet at a higher state of evolution than ourselves. Certainly, they may have visited this planet in the past, but we have no proof that they did, or did not, do so. And we certainly have no proof that the ancient people wrote them into their mythology as all-powerful gods.

Perhaps, one day, the visitors from afar will return and solve the mystery once and for all.

Dancing figures, that could be likened to space men, have been found in a cave in Italy (above).

Some people see a similarity between the American space man (right) and the crude drawing below it, which was seen at Tassili in the Sahara.

The great idol (below) at Tiahuanaco in South America is said to have inscribed upon it astronomical facts that could not have been known to the Incas, the suggestion being that the facts came from others with a higher intelligence than the Incas.



If an Earthman landed on a distant planet, inhabited by primitive people, would he be regarded as a strange god from the skies?

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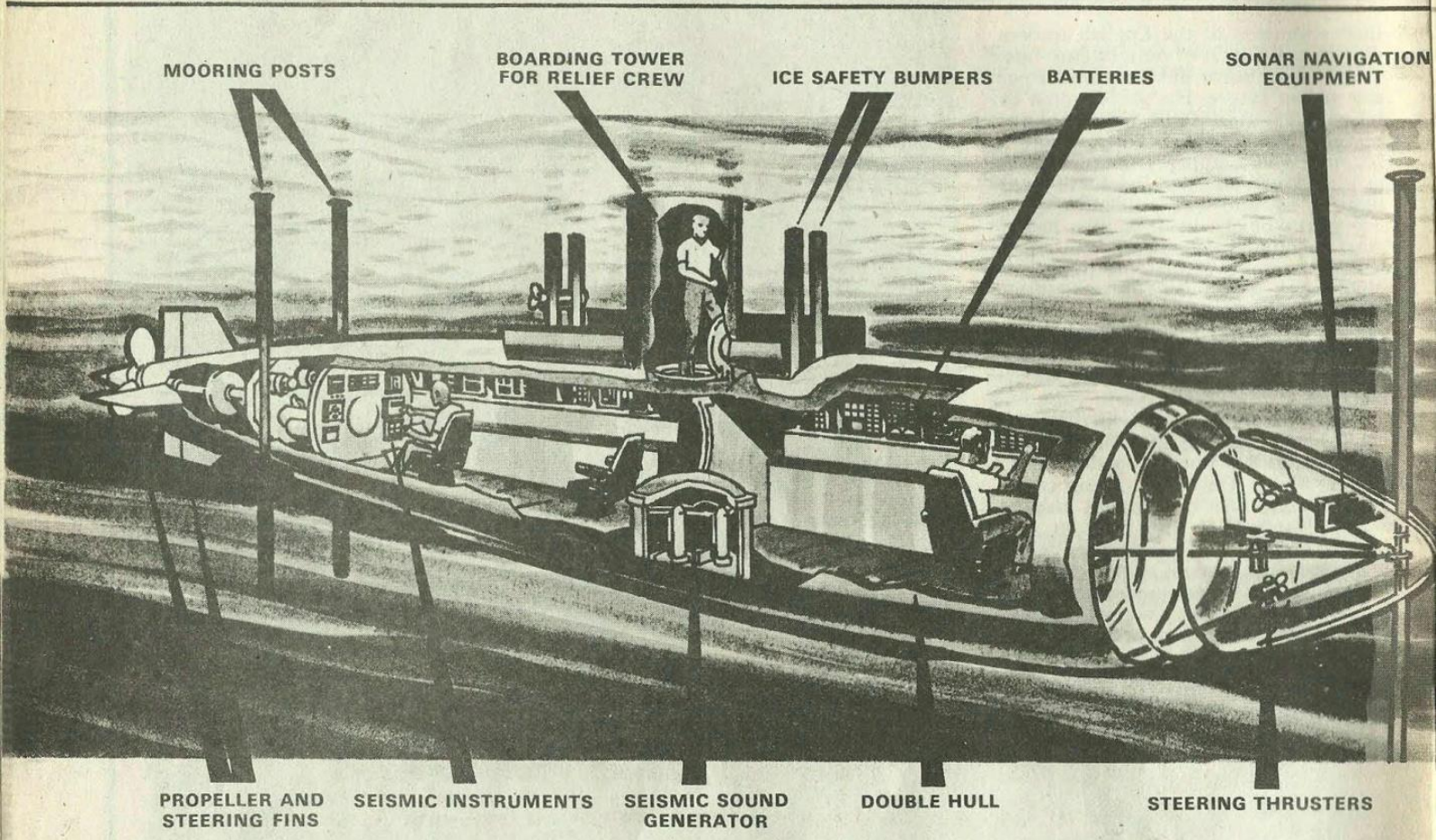
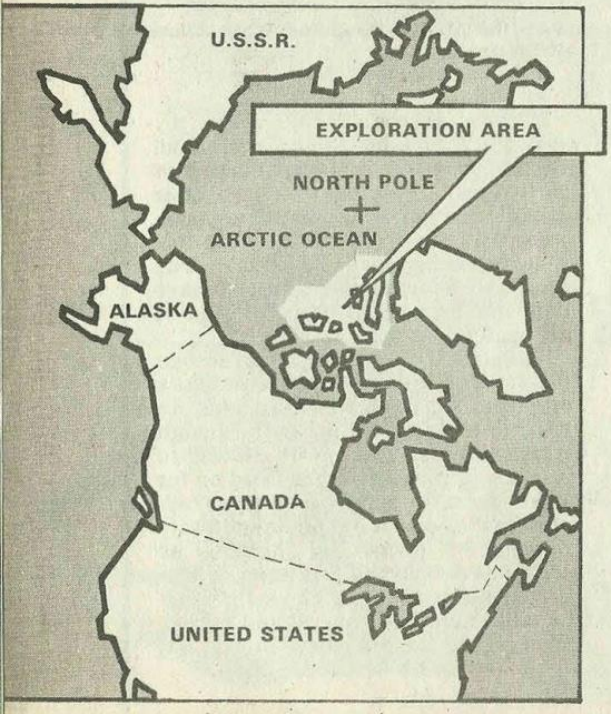
THE WORLD IN CONFLICT

THE STORY OF THE SECOND WORLD WAR BEGINS INSIDE



UNDER THE ARCTIC ICE



A submarine which will search for oil and gas beneath the ice of the Arctic Ocean has been developed in Canada

MILLIONS and millions of cubic feet of natural gas lie buried beneath the Arctic Ocean, according to an estimate made by geologists. Vast reserves of oil may also be locked under the ice.

The first step in any search for oil and gas is a seismic survey. As a rule, the explorers set off an explosion and instruments chart the path of the echoes through the earth. Their readings show the likelihood of oil or gas deposits.

But in the Arctic, the ice interferes with the results by making big, unpredictable distortions. To overcome this, the Canadian government, in whose area the prospecting is taking place, asked designers to invent a submarine that could work under the ice. The result is Narwhal II, a 45 ft. long steel vessel powered by electric storage batteries and manned by a crew of three.

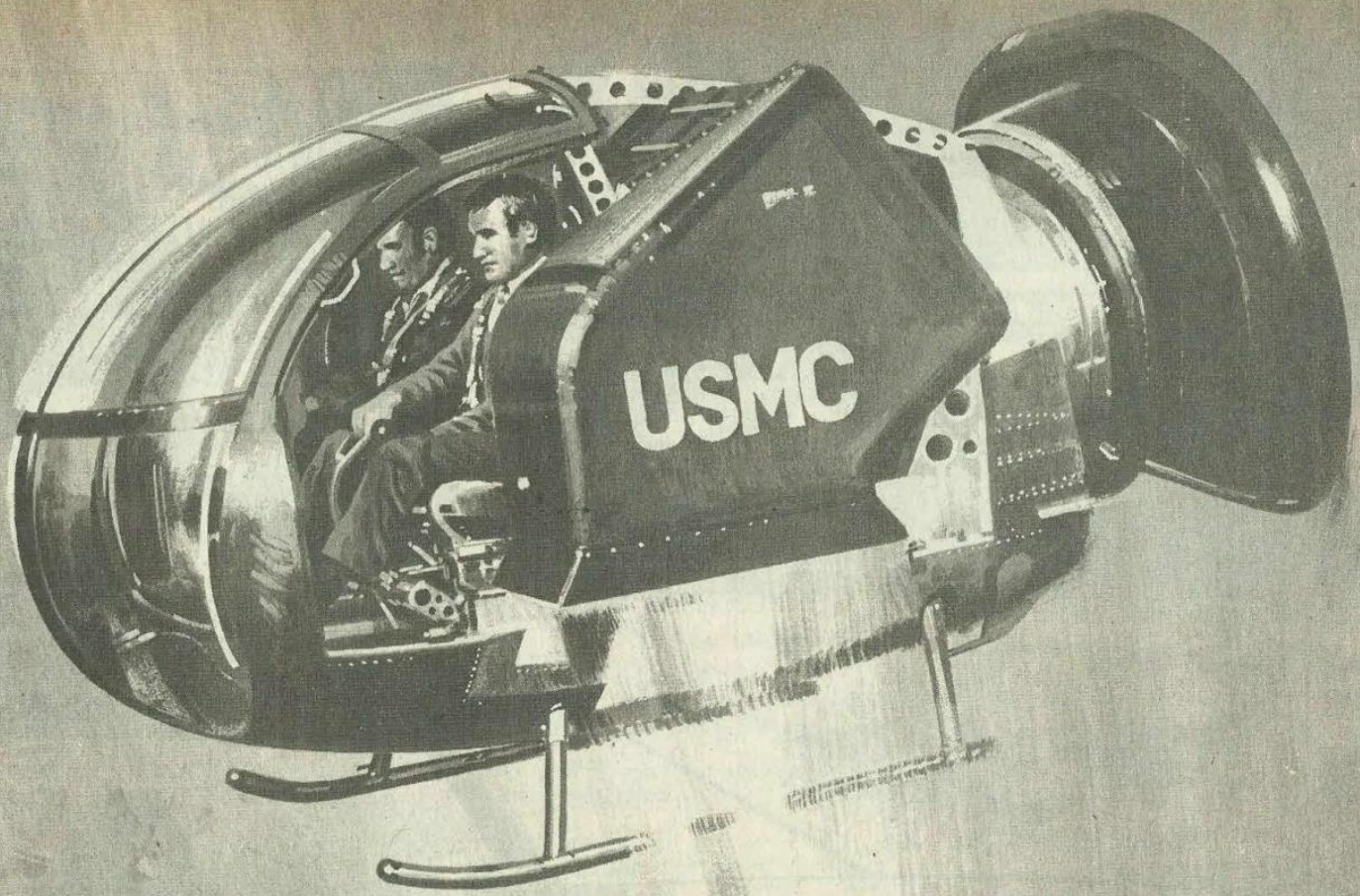
To launch the submarine, a hole will be cut in the ice, which is about seven feet thick. The submarine will then be lowered through this hole into the ocean below where it will be able to operate for up to ninety days at depths of 100 ft. to 200 ft.

The seismic surveys will be made with the help of a piston in a cylinder which makes a low frequency signal that bounces off the seabed every 20 seconds. Trailing behind the submarine will be a half-mile long, sensing cable that will pick up the echoes.

After its trials, the submarine is to begin work in the Queen Elizabeth Islands where it should be able to conduct a four thousand mile survey in three months. Crews will be exchanged through a support tower let into the ice.

Many big oil companies are expected to book exploration time on the submarine. If big finds are made, oil rigs may be built on the ice.

Insulated with plastic foam and wood matting, the ice is then able to support a 500 ton rig capable of drilling to 7,000 feet. Vast pipelines would then have to be built to carry the oil and gas across the ice to the users.



THE FLYING JEEP

A startling new vehicle may carry the American marines into battle in the future — an airborne jeep

HAS the flying jeep arrived at last? After many attempts to devise a small flying vehicle, the Americans have produced the Garrett's Stamp (small tactical aerial mobility platform).

This is a vehicle with the fuselage of a helicopter but without the rotor system, engine or tail boom. Instead of these, it has a powerful turboshaft engine. This drives a ducted fan which sucks in air at the rear of the fuselage and mixes it with the hot turbine exhaust. The mixture is divided into two streams which pass on either side of the fuselage through twin-branched ducts.

In each branch of the duct are two deflectors to direct the flow downwards to sustain the vehicle in flight. Another deflector in each duct can be used to divert the flow for manoeuvring.

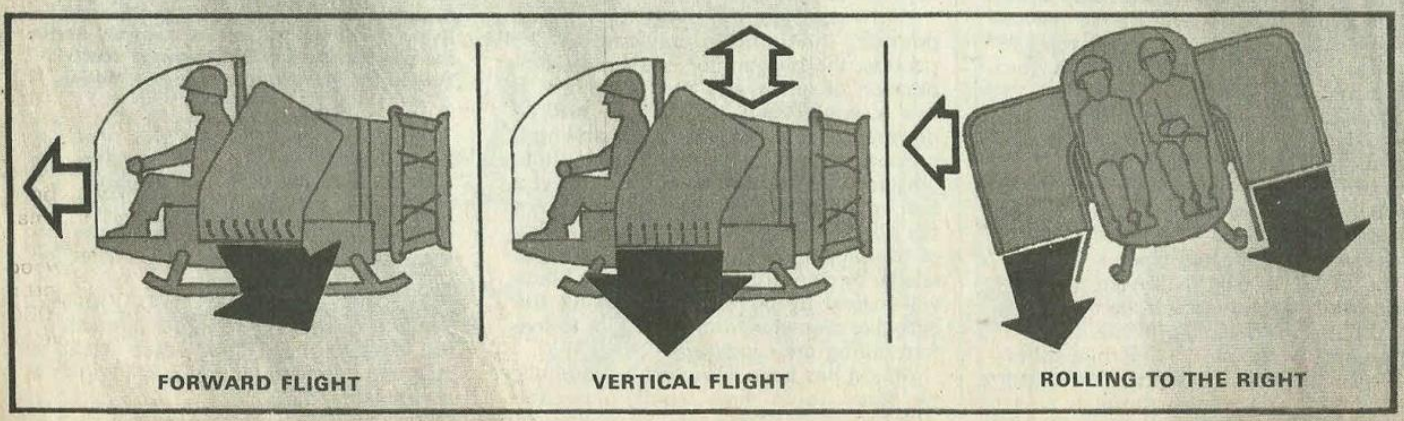
To make the vehicle pitch or roll, there are diverter plates in the airflow which are moved by the pilot's controls.

The flying jeep was made for the United States Marine Corps and it could obviously be used in areas where ordinary aircraft could not land. Short flights from ship to shore, or from a remote island where the marines may have made a landing to a nearby ship, could be among its uses.

So far, only a prototype flying jeep has been made and this flew for only three minutes. This was sufficient, however, to show that the vehicle had possibilities. It was built to a tight budget and was made as simply as possible. Nevertheless, it is described as manageable. Yaw control — the ability to keep to its course — is said to be good. But pitch control is marginal and it is skittish in roll.

What makes the flying jeep distinctive is the fact that it breaks away completely in design from either fixed wing aircraft or helicopters. It borrows its idea of jet propulsion from conventional planes and its body from a helicopter. But it also owes something to the hovercraft. And it may well prove to be the flying mini-car of the future.

The flying jeep showing, from left to night, below, the direction of the thrust for various forms of flight.



SCIENCE SURVEY
Continued

Pollution high above the Earth is to be tested by a pilotless plane which will sample the exhaust from mighty jet planes

SNIFFING THE STRATOSPHERE

WHAT is it like fifteen miles up in the stratosphere after a powerful jet plane has streaked through the sky? Does the pollution from the plane reach intolerable limits?

America is planning to find the answers to these questions by sending up into the stratosphere a pilotless plane which they are calling a mini-sniffer. Its job will be to fly in the wake of big planes like the USAF/Lockheed YF-12 prototype to take samples of the big plane's exhaust.

The YF-12 is being used as a supersonic test-bed, and tests of the emissions from this plane will help in the study of high altitude pollution. The mini-sniffer will also be able to sample the upper atmosphere after an earthquake or an atom bomb test.

With its take-off weight of 145 pounds, including a payload of 25 pounds, the mini-sniffer is a super combination of glider and model aircraft. It has a wing span of 18 feet and is powered by a two-stroke motor driving a propeller. Two facts make this plane outstanding. One is the engine's use of a fuel which does not need oxygen from the atmosphere. The other is the ability of the propeller to be extended automatically by centrifugal force. Each blade will extend by one foot, increasing the propeller diameter from three foot to five foot during the climb.

After it has been launched by catapult, the plane would climb rapidly under the supervision of a pilot who operates the controls by radio from the ground.

The mini-sniffer in action. Above right: the pilot at the controls on the ground flying the plane by remote control. Above: the plane and its pilot drawn to scale. This is the full-size plane, not a model.

A small television camera will be mounted in the leading edge of the left wing to help the ground pilot to steer the plane into visible wakes.

To reach a height of 100,000 feet would take about 44 minutes and use all the plane's fuel. It will then make a spinning descent and end by gliding to a horizontal landing.

THE FLYING CRANE

SUPPOSE you wanted to carry a heavy piece of machinery quickly to a clearing in a forest, or transport a large vehicle from a ship to a rocky shore, how would you do it?

A helicopter would not be powerful enough and a balloon would not have the lifting power. But the job has got to be done and the answer, put forward by an American company, is to combine these two lifting devices.

The result is the helicopter-balloon you can see in our picture and which is still on the drawing board. However, after a model has been made and proved that the idea is workable, a full-sized version is to be tested.

Called the Aerocrane, it will consist of a helium-filled balloon with a diameter of 180 feet. Fitted to it will be a helicopter containing four powerful (4,000 shp) turboprop engines and four 126 feet-long rotor-wings. This could lift a load of 180,000 pounds and carry it forward at a speed of 47 mph. Forty per cent of the weight would be taken by the balloon and the rest by the lifting power of the helicopter.

In order to rise from the ground, the entire aerocrane would have to rotate about its vertical axis at 8.6 revolutions a minute. As it rotated, the rotor-wings, supported by a structure within the balloon, would go through the cyclic pitch changes similar to a conventional helicopter.

Because the helicopter provides 60 per cent of the lifting action, the aerocrane will be able to climb, descend, drop a load or pick it up without the need for shifting ballast, as in a conventional airship. By changes in the pitch of the propellers, the aerocrane will be able to generate the force to lift a load, or to counteract the lifting power of the balloon when descending to collect its cargo.

Both the American Navy and the U.S. Forest Service is interested in the aerocrane. They have asked for a small-scale flight model to be made so that it can be examined. The model will have a 14 foot diameter balloon and 8 foot-long rotor-wings: powered by four electric model aeroplane motors, each rated at 0.25 hp. If this is successful, then the go-ahead will probably be given for the full-scale aerocrane.

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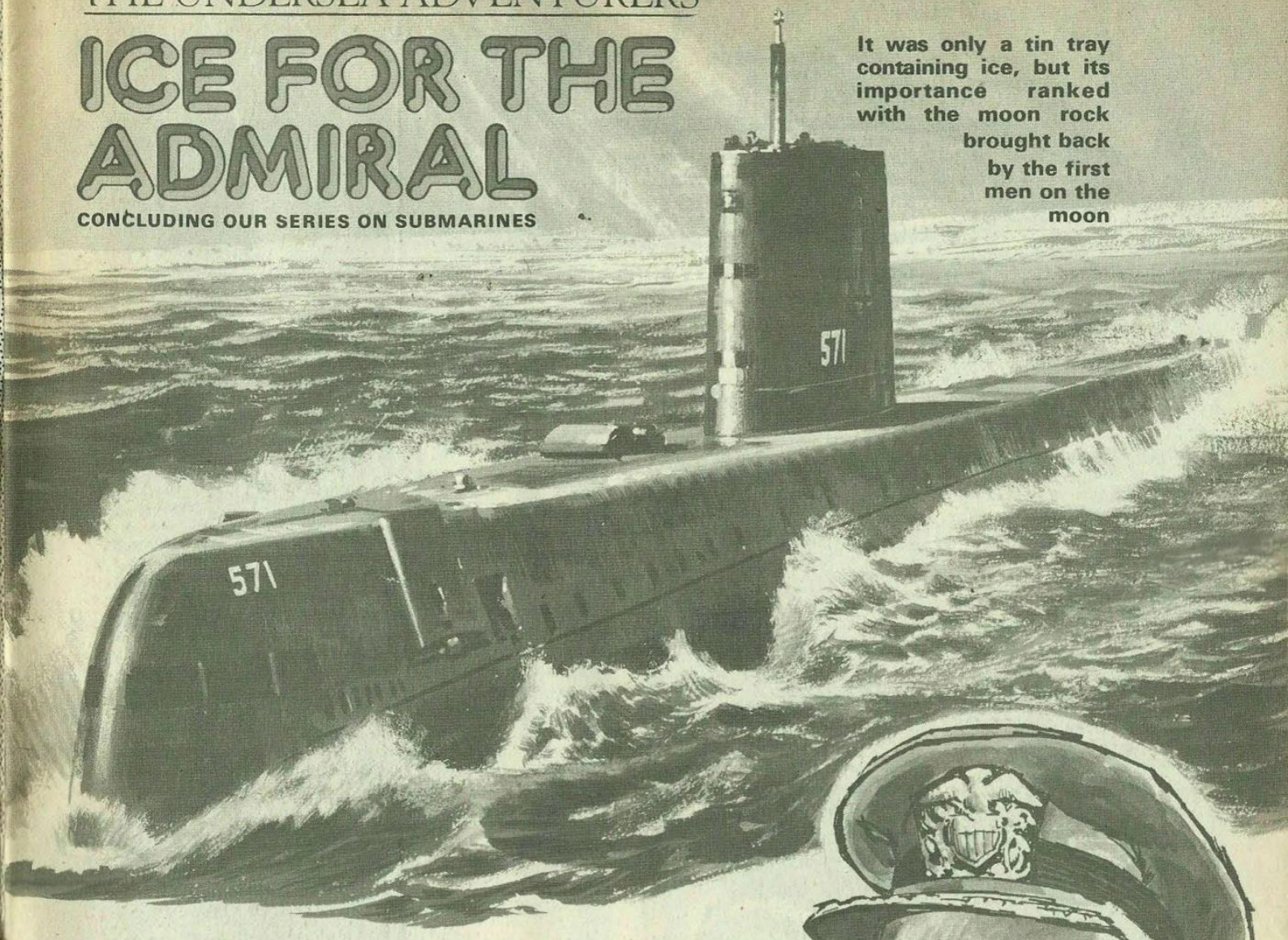
It was only a tin tray containing ice, but its importance ranked with the moon rock brought back by the first men on the moon



IN August, 1958, the American admiral Hyman George Rickover (right), went aboard a submarine in New York Harbour for a most unusual presentation ceremony. He was handed a tin tray of ice from the ship's refrigerator. Not much of a present, you might think, but this was very special ice. It had been taken from the polar ice pack in the Arctic Ocean. The submarine was the U.S.S. "Nautilus" (above). She was the world's first atomic-powered submarine and had just returned after voyaging to the North Pole under the ice.

Admiral Rickover was keenly interested because he had fought for years to get the "Nautilus" seaworthy. In 1946, Captain Rickover, as he then was, had been enthusiastic about the atomic reactor as a submarine power-plant. The only trouble was that he could find few people who shared his ideas and enthusiasm.

One of the chief advantages was that an atomic-powered submarine could remain submerged indefinitely, and still manoeuvre at high speeds. All this could be done on a pound of uranium which equalled 2,600,000 pounds of coal or 360,000 gallons of petrol.

Rickover bulldozed his way through the various financial and technical problems which arose on the way. After years of frustration, disappointments and setbacks, a working reactor was finally put inside a "mock-up" submarine and tests on dry land proved successful.

On June 14, 1952, the keel of the first atomic submarine later to be called "Nautilus" was laid in the Groton Yard, Connecticut, U.S.A. On January 21, 1954, Mrs Mamie Eisenhower, wife of the American President, performed the launching ceremony.

"Nautilus" floated out into the river, still floating high because her nuclear "heart" was not yet installed. The great moment came on January 17, 1955, when she glided, silently, stern-first, away from the fitting-out bay.

It was an historic moment. From her conning tower flashed a signal. "Under way on nuclear power."

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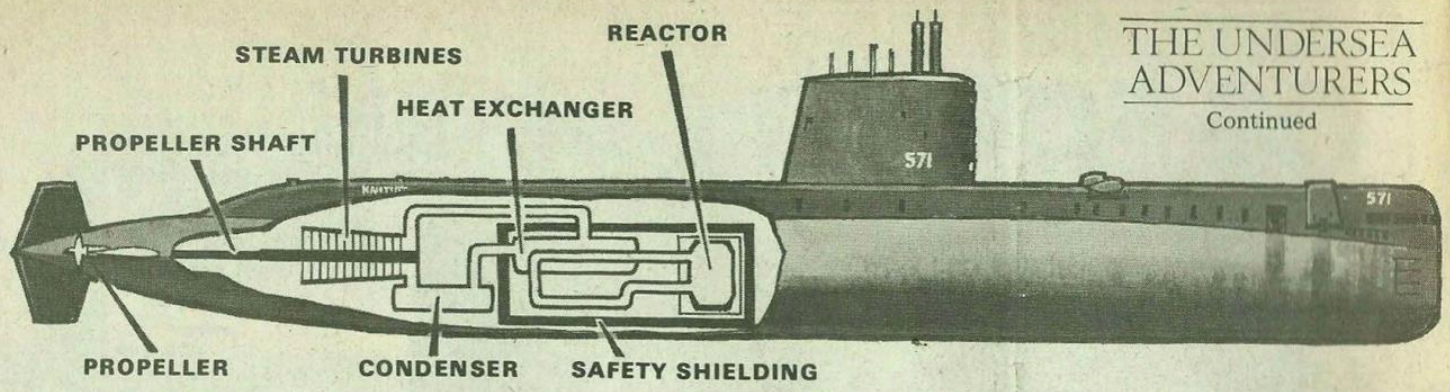
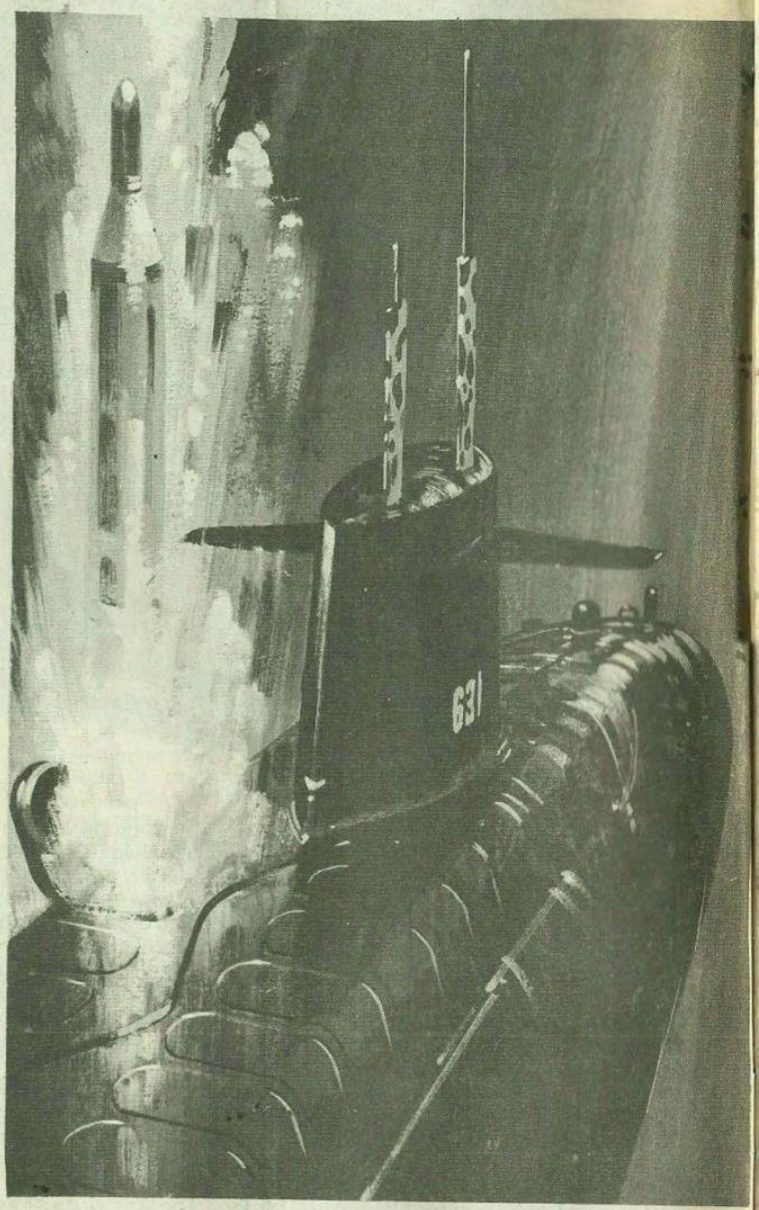
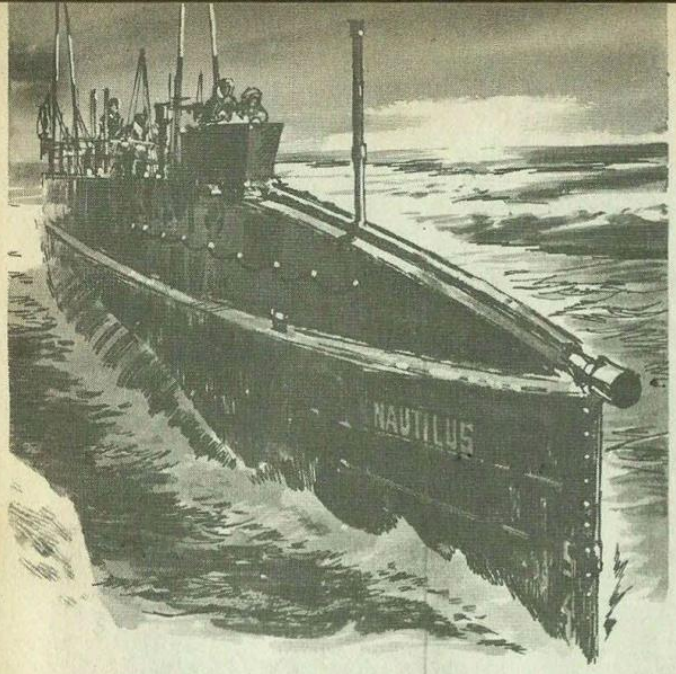


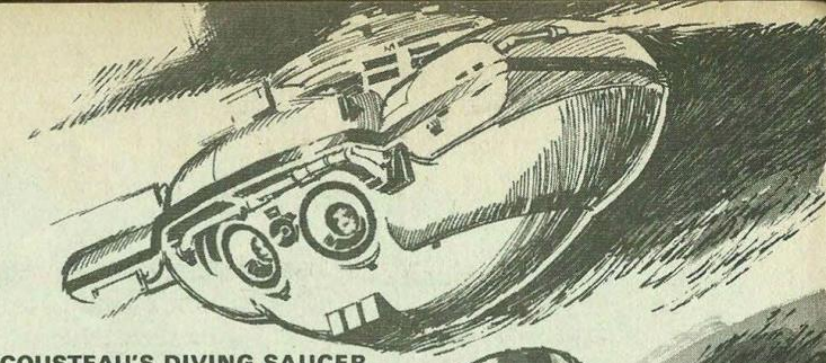
Above, we see an atomic power system superimposed on a side view of U.S.S. "Nautilus." The safe, controlled nuclear fusion in the sealed reactor cone produces intense heat to make steam to drive turbines. The reactor heats water in a sealed system which is prevented from "flashing" into steam and instead, transfers its heat to a second water system which *does* vapourise into steam and is fed at high pressure to turbines which spin to drive the propellers. The steam is condensed back into water and circulated again for re-use. The heavily-shielded reactor and its sealed water system remain untouched for years between uranium refuellings. All moving parts are "lubricated" by the circulating hot water.

The exploits of the nuclear subs are already legendary. Their unique ability to go under and stay under and the electronic navigation and sensing equipment packed into them, made them ideal for spectacular exploits which, while producing massive publicity, also made excellent training tasks for their crews. On August 3, 1958, U.S.S. "Nautilus" reached and crossed the North Pole under the Arctic pack ice. On March 17, 1959, U.S.S. "Skate" (above), broke through the ice at the Pole and surfaced there. On April 25, 1960, U.S.S. "Triton" surfaced off the North Atlantic coast of America, having made the first *submerged* voyage round the world, and covered 26,723 nautical miles.

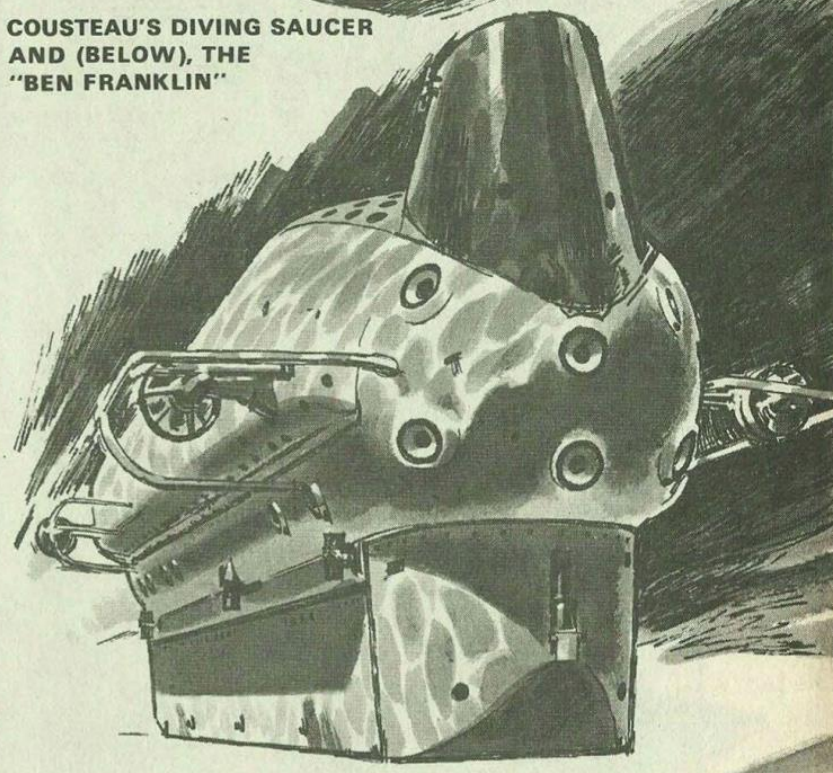


The atomic submarine soon took on a sinister new role, that of underwater missile-launching platform. The first of these vessels were built for the U.S. Navy and classed as Fleet Ballistic Missiles. (FBM). Today, such weapons are possessed by the navies of America, Russia, Britain and France. The "Polaris" (seen above), can guide itself thousands of miles and then shower nuclear warheads and decoys on to its target. The navigation equipment needs to be incredibly accurate because the missile's guidance computer must be told precisely where it is to go. The system is "inertial," using ultra-sensitive detectors to record each movement of the vessel from its starting point and so pin-pointing its position all the time.





COUSTEAU'S DIVING SAUCER AND (BELOW), THE "BEN FRANKLIN"

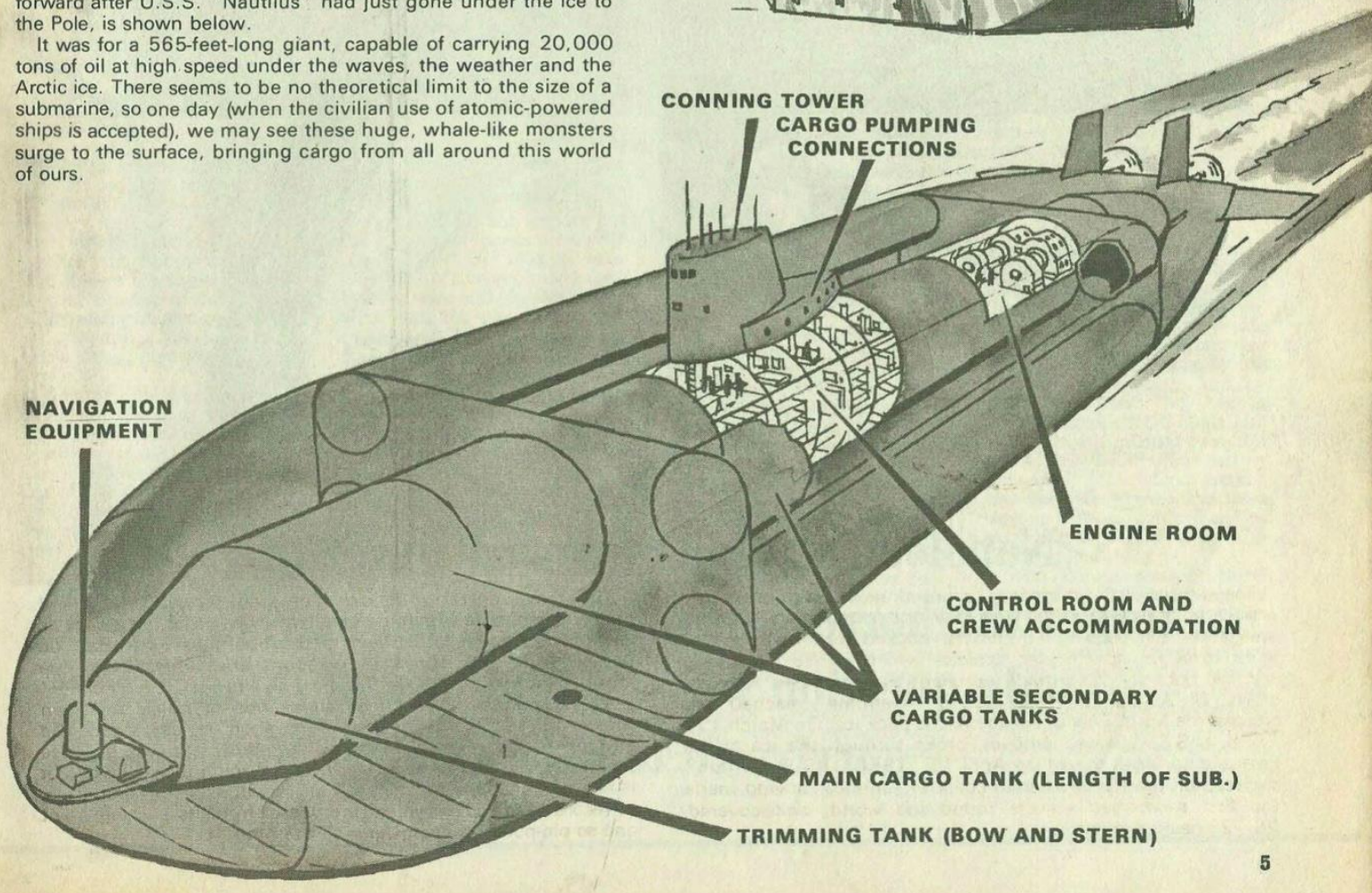


In 1931, the Australian explorer, Sir Hubert Wilkins, obtained an outdated submarine from the U.S. Navy, christened it "Nautilus" and took it into the Arctic ice pack for three weeks of exploration and research (see above.)

Modern exploration, archaeology, research and "prospecting" have produced a range of small subs of all shapes and sizes, some loaded with floodlights, cameras and remote-working claws. The most famous of all is Jacques-Yves Cousteau's two-man diving saucer. The illustration on the right depicts the "Ben Franklin" whose design missions included drifting with the warm currents of the Gulf Stream.

Many schemes have been studied for giant atomic merchant subs but none has yet been built. One such design, put forward after U.S.S. "Nautilus" had just gone under the ice to the Pole, is shown below.

It was for a 565-feet-long giant, capable of carrying 20,000 tons of oil at high speed under the waves, the weather and the Arctic ice. There seems to be no theoretical limit to the size of a submarine, so one day (when the civilian use of atomic-powered ships is accepted), we may see these huge, whale-like monsters surge to the surface, bringing cargo from all around this world of ours.



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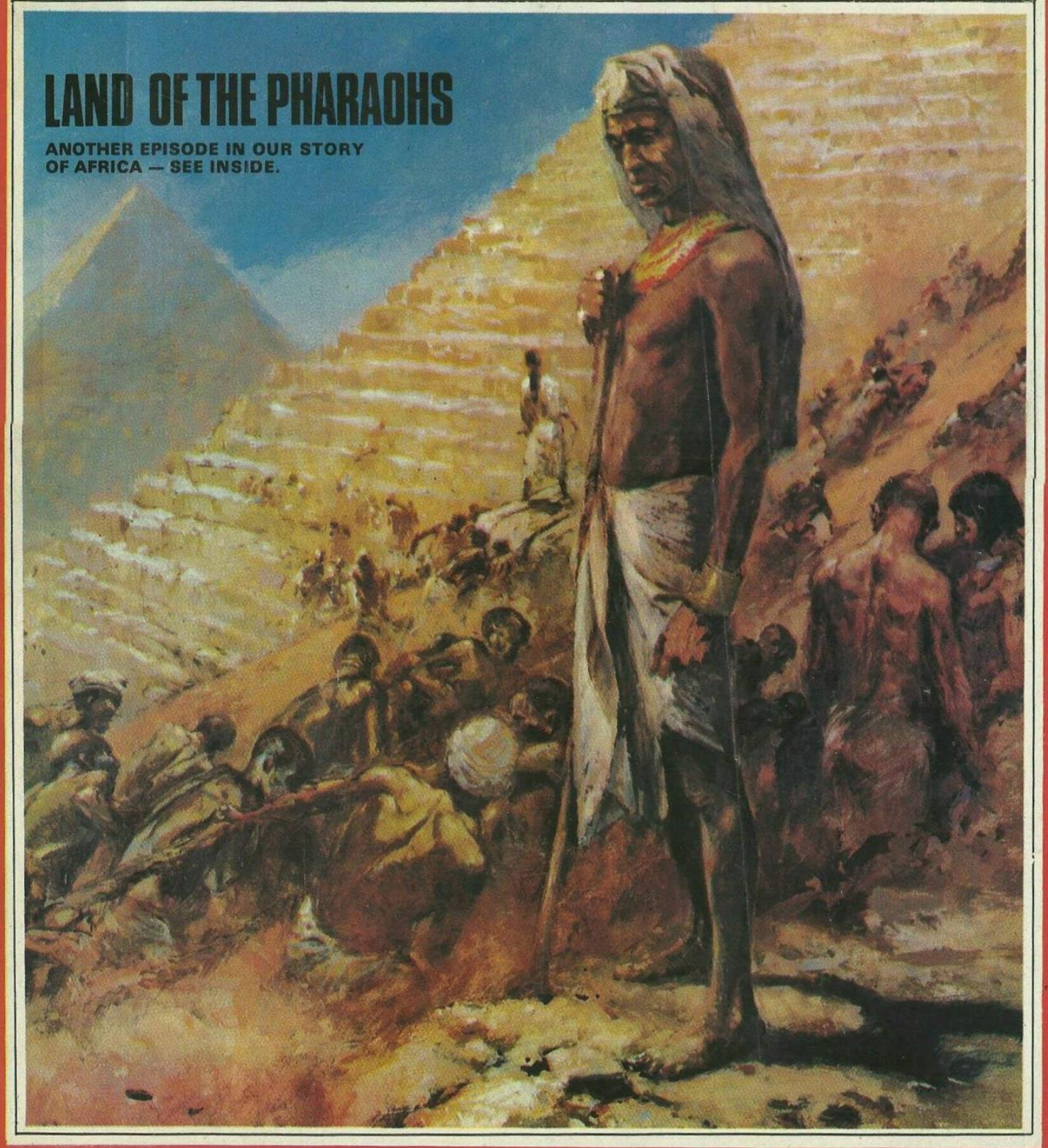

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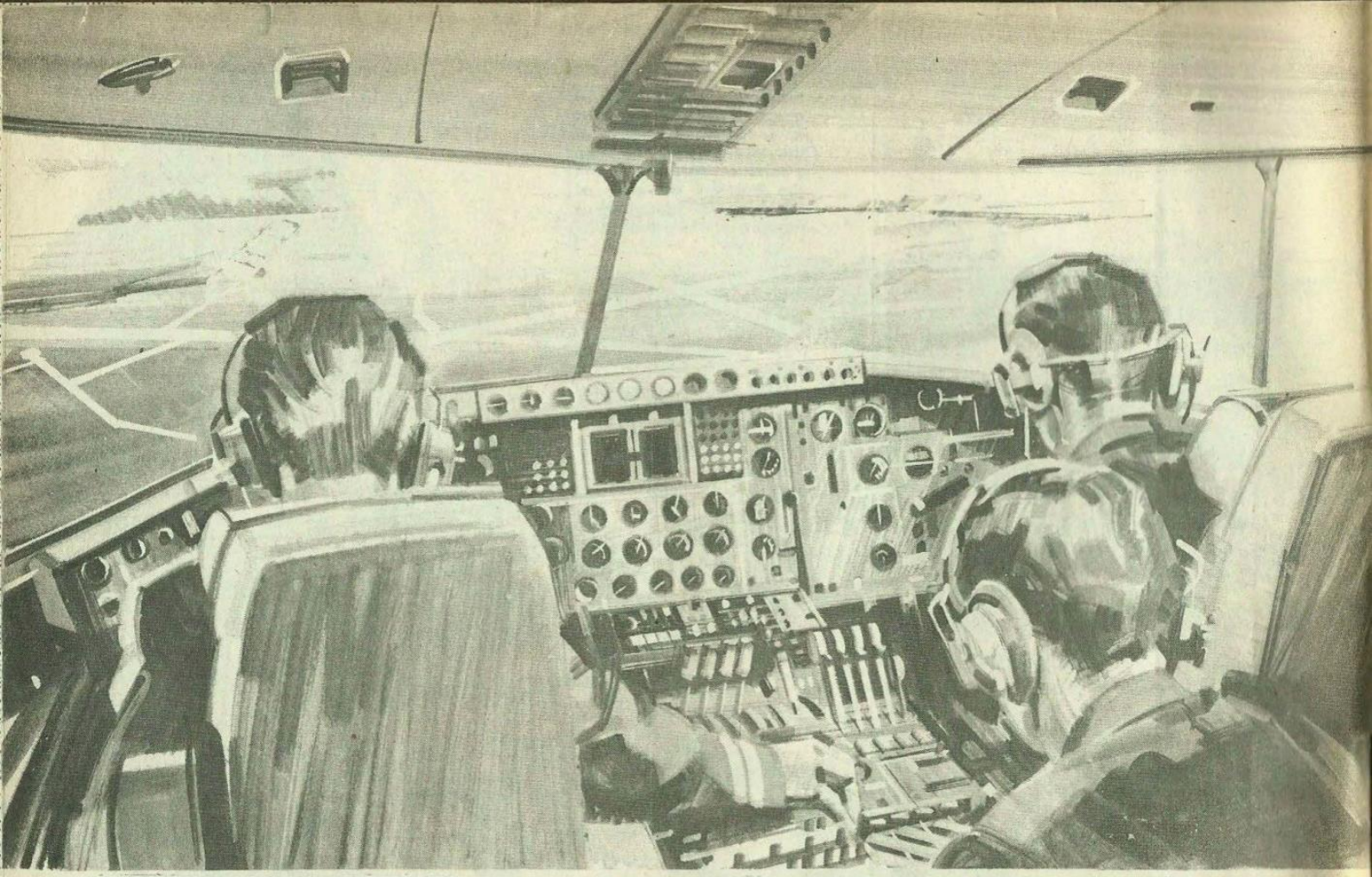

The flight deck of a big jet plane? No, this is the cockpit of a training machine which imitates flying conditions

SCIENCE SURVEY

GOING PLACES-BY SITTING STILL!

Space men, pilots and tank drivers are taught how to use their complicated vehicles with the aid of simulators — machines which create the impression of travel and yet always stay in one place

GENTLY the plane taxied along the airport runway. The pilot could sense the buoyancy of the tyres on the tarmac. Then there was an almost imperceptible change in sensation as the ground fell away and the mighty jet engines thrust the plane heavenwards.

Now the airport was a tiny patch among the streets of miniature houses with green fields beyond. To the pilot making his first flight as the captain of the crew of a big jet, the take-off had been a demanding hurdle. And he was just congratulating himself upon having overcome it when a voice on a loudspeaker said, "That was fine, Joe. But I'd just like to go over a couple of points with you."

With a wry grin, the pilot stood up and stepped out — not into space but on to a portable ladder at the bottom of which his instructor was waiting. For, far from being high in the sky, he was in a training building. And the "plane" he was "flying" was not a plane at all but a device called a simulator.

Because modern jet planes are such costly machines, they cannot be spared for the training of air crew. Instead, the pilots and the other officers gain their experience in a simulator. They sit in a cockpit — or flight deck — which is an exact imitation of the cockpit of a big jet with all its controls and instruments.

Through a loudspeaker, they hear the sounds of the jet motors and before them, on a screen, they can see the land and the sky just as if they were really flying.

As they move the controls, their cabin rolls and pitches, tilts when it "climbs" and inclines to one side when it banks, just like the cabin of an actual plane.

Pilots of both civil and military planes do some of their training in simulators, which have cockpits which are like those of many famous aircraft.

* * * * *

And before the Americans first landed on the Moon, they had been through the procedure many times in a simulator. Perhaps you remember Neil Armstrong saying as the lunar module made its descent to the Moon. "Everything is going A-OK. It throttles down . . . better than the simulator."

The simulator employed in training the astronauts for their moon landing was the most sophisticated ever built. But simulators just as efficient have been made to train people in other fields as well. Some are used to train deck officers on merchant ships, employees on atomic power plants, drivers on the American railways and young car drivers.

They are now being used to train soldiers to drive tanks and other armoured military vehicles.

One, made in Britain, is based on the Chieftain tank. It consists of a faithful reproduction of the driver's compartment complete with controls and instruments, and facilities to give the impres-

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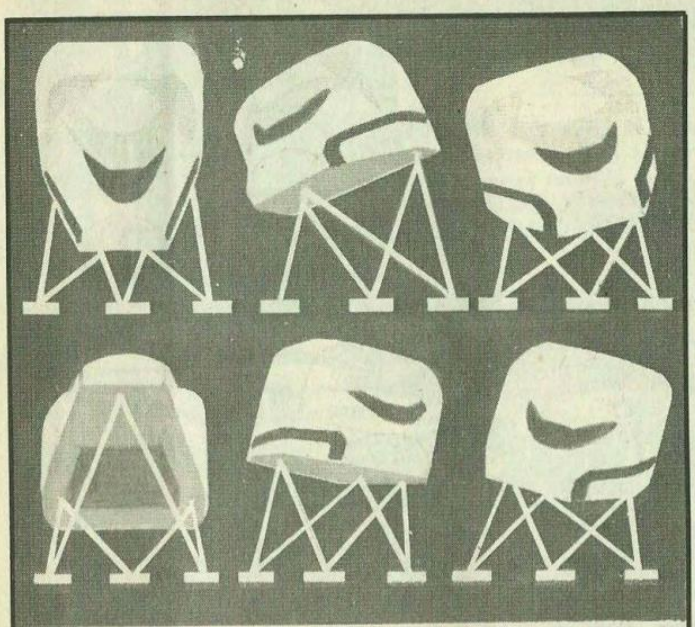
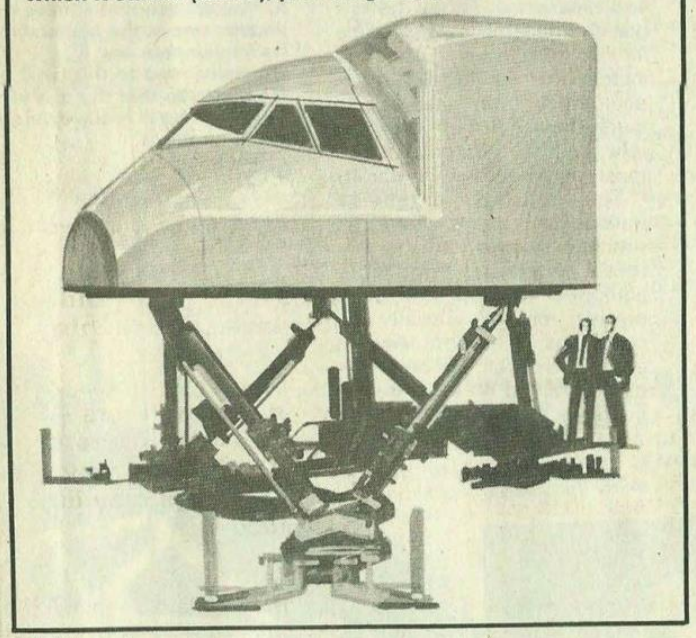
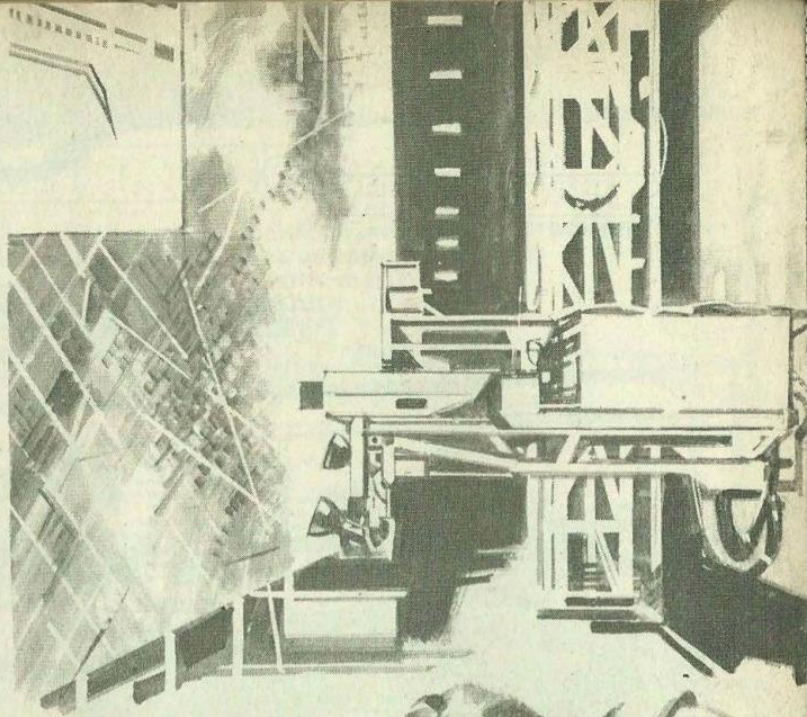
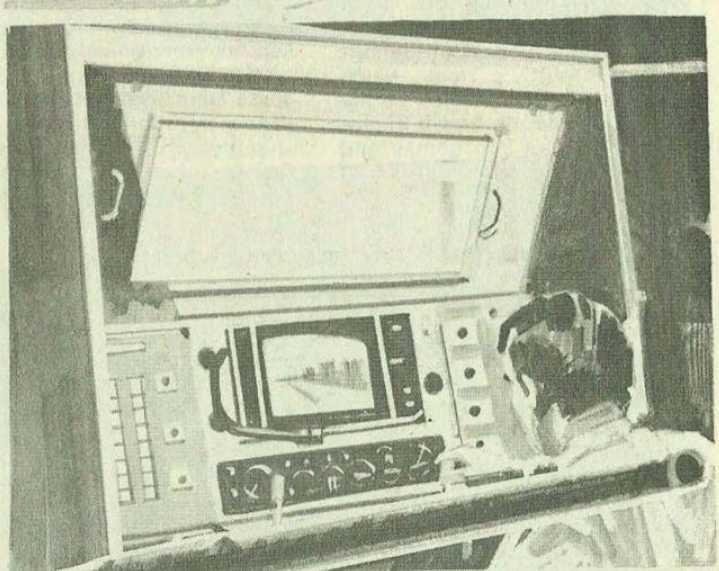


The simulator (below) is made to copy the movements of an aircraft through its controls which manipulate the four legs on which it stands (above), providing roll, pitch and heave.

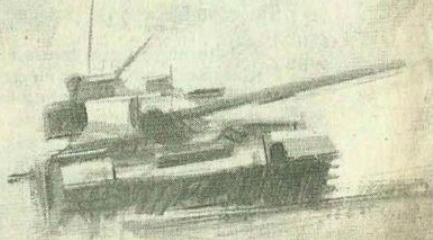


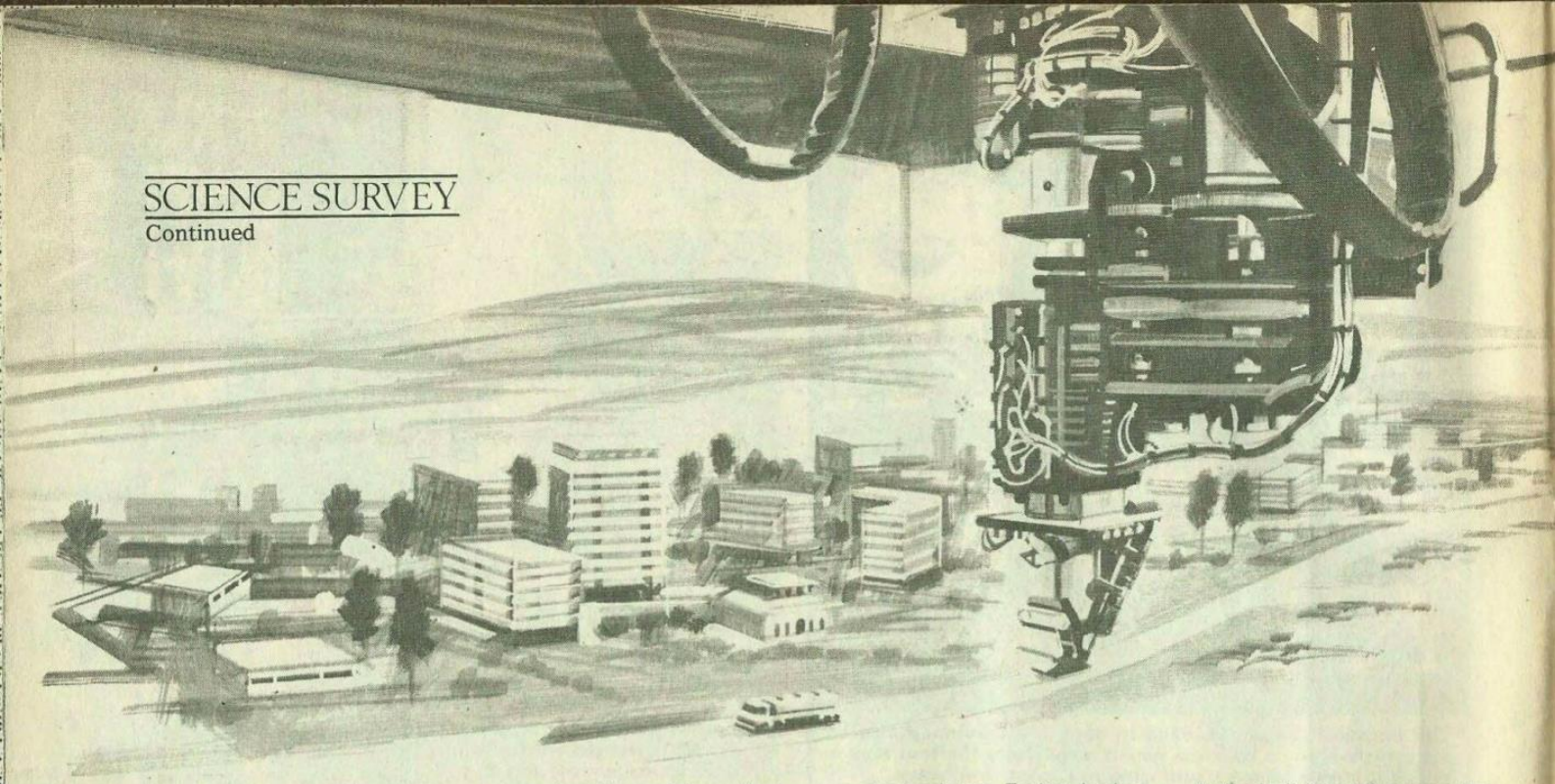


For the tank simulator, the terrain is erected vertically to save space (above) and is viewed by a TV camera. Right: a skilled model-maker at work creating the realistic landscape.



A simulator (above) is used to train the men who drive the mighty British Chieftain tank (left) so that they can handle their giant vehicle with complete confidence.





sion of movement. On a TV screen in front of him, the driver sees a picture of the country he is "driving" through.

What he is actually seeing, though, is a model of the terrain relayed by a TV camera, and it is the camera which moves over the model to give the impression of movement.

The unevenness of the surface is felt by a "foot" which runs over the surface of the model. The movement of this is converted into bumps and jerks in the cabin to make it seem that the tank is really in motion.

Strange as it may seem to those who know little about them, flight simulators are not new. The man generally credited with inventing the first of them is an American, Edwin Albert Link, who made a machine he called a "pilot-maker" in 1929. Since then, thousands have been supplied to civil airlines, the armed services, to the US space administration and to various transport industries.

In the early days, an airman flew by observation, instinct and experience. Today, he is a qualified technician who relies almost exclusively on his instruments, radio and radar equipment from take-off to touch-down. But in order to rely on his equipment, he must first know how to use it.

This requires extensive training, and this is where the simulator comes into the picture, for it is admirably equipped to duplicate with precise realism virtually all conditions of flight. And it ensures that all air crew are highly trained — even before they take to the air.

A "feeler" (above) senses the undulations in the landscape. Its movements are communicated to the tank simulator so that the driver feels that he is really driving along a road.

Before astronauts landed on the moon (right), they practised their manoeuvres many times in a simulator (above) which realistically reproduced the performance of the lunar landing module.

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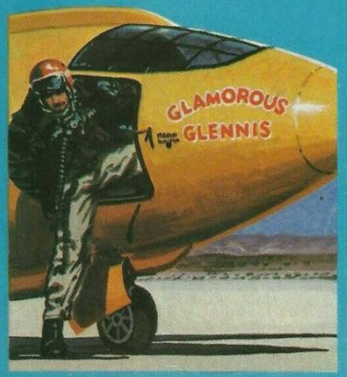
FLYING FIRSTS

THE BIG BANG

Planes crashing through the sound barrier with tremendous bangs that resound on Earth are features of modern life. But when Chuck Yeager approached the speed of sound for the first time he was flying into the unknown

CAPTAIN Charles "Chuck" Yeager sat in the cramped cockpit of his XS-1 rocket-powered research aircraft at 9,000 metres above the Mojave desert in the eastern United States on 14th October, 1947.

Above and around him was the vast form of a huge B-29 Superfortress bomber, the XS-1's mother ship. Behind Yeager's back were the XS-1's fuel tanks containing a mixture that was to blast him through the air faster than any man had gone before.



Captain "Chuck" Yeager named the XS-1 "Glamorous Glennis" after his wife. Its bright yellow-orange colour was to make it easy to spot in the air.

1 Dawn take-off with the XS-1 clamped to the Boeing B-29 mother ship, and a chase plane close at hand.

2 Yeager squeezes down into the XS-1's tiny cockpit to begin the countdown.

3 Time to go. Three, two, one . . . drop.

4 All four rockets firing, Yeager accelerates into the sledge-hammer vibrations and on into the smooth region beyond the speed of sound.

5 Back home to the Muroc dry lake bed for a tricky "dead stick" (no power) landing at about 190 mph with no second chance.

Today was the day. Today, Chuck was determined to smash the sound barrier once and for all. In some ways, his XS-1 was more like a bomb than a plane. Not only was it carried by a converted bomber, then dropped before starting up its motor, but its fuel was so explosive that it could blow the plane and its mother-bomber to fragments if anything went wrong.

Liquid oxygen, pure alcohol and raw hydrogen peroxide was the devil's brew which made the XS-1 a very dangerous aeroplane.

Chuck did not get into his plane until the B-29 had climbed above 2,400 metres. He strapped himself into the cockpit, locked the tight-fitting hatch and linked himself to his oxygen supply and G-suit connections.

"Sixty seconds to drop," came the captain's curt voice over the earphones.

"Fuel shut-off valve open," said Chuck, as he went through his part of the countdown.

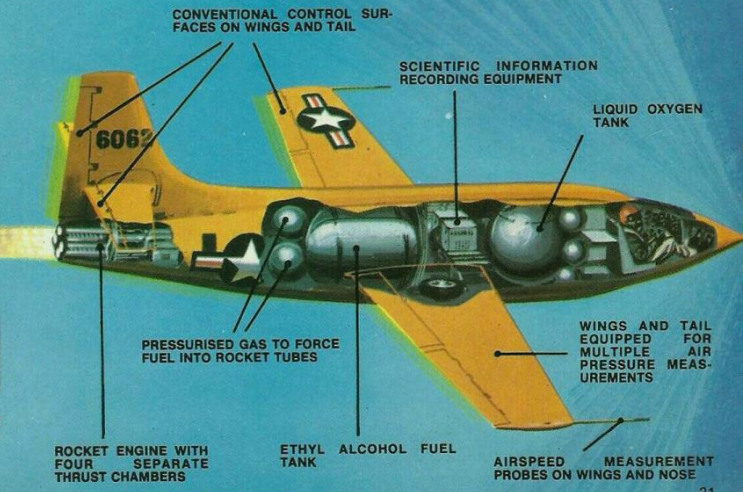
Moments ticked by. Then the XS-1 fell into space. Chuck opened up to full throttle. With a bang that hit Chuck like a giant's fist, the XS-1 shot forward. As its speed mounted alarmingly, the craft began shaking violently.

Gritting his teeth, Chuck let the plane go even faster. Glancing at his instruments, Chuck saw that he was nearly there. The shaking became almost unbearable. Then suddenly it stopped.

He was flying at faster than the speed of sound, and the sound barrier had proved to be no barrier at all. The XS-1 was flying as smoothly as she had ever done, cutting through the air like a knife.

Chuck's speed was Mach 1.015, or 670 mph at an altitude of 42,000 ft. (12,800 metres).

The mysteries of the sound barrier no longer existed. But other dedicated test pilots like Chuck Yeager were needed before the terrors of supersonic flight were finally removed forever.



Captain Charles "Chuck" Yeager (above) and (right) a simplified cutaway of his Bell XS-1 rocket plane.

THE WONDER WORLD OF SCIENCE

SKYSHIPS OF THE FUTURE

Mammoth airships, some shaped like discs and others with deltoid or cigar-like forms, are being planned as the cargo and passenger carriers of tomorrow to reduce pressures on ports and existing road systems

IF you are a "flying saucer" observer, a new-style of British cargo and passenger craft could confuse you. Shaped like a monster saucer, such vessels have been designed to succeed the Zeppelins and other inflated airships which crashed or were withdrawn from regular service earlier this century.

"Skyships," as the new craft have been named, are the work of a design team led by John West. They are envisaged as being 720 ft. (219 metres) across, with a maximum thickness of 180 ft. (54 metres) and carrying enough cargo to create a total weight of anything between 600 and 800 tons, depending partly on the amount of fuel aboard. The engines, standard gas turbines running the propellers, are planned to use natural gas, and the speed of the skyships will be about 90 m.p.h. (144.8 km/hr).

That's much slower than other aircraft today, but is considered likely to make the services profitable with a degree of safety unmatched by any other form of air transport today. Indeed, the skyship is intended to be the safest aircraft in the world. The principles on which it flies, its shape, and other aspects will combine to create this desirability.

In addition to being a safe vessel, the skyship is regarded as an ideal means of solving the transport problems of the newly-formed nations. It is simple to load; and loading and distribution points can be located at convenient spots all over the globe. It will reduce pressures on ports and existing road systems.

And you are probably aware that today there is considerable emphasis on restricting air pollution and noise. Skyships are commendable because they would have engines of comparatively low horse-power, together with low speed propellers. So these aircraft would be relatively silent and pollution free.

Skyships are expected to take off and land on a circular pad covering about ten acres (approx. 4 hectares). Visit a pad and you would see anchorage points arranged round its edge, with skyships attached to them by hawsers. The vessels will contain synchronised winches to let out or draw in these stout ropes.

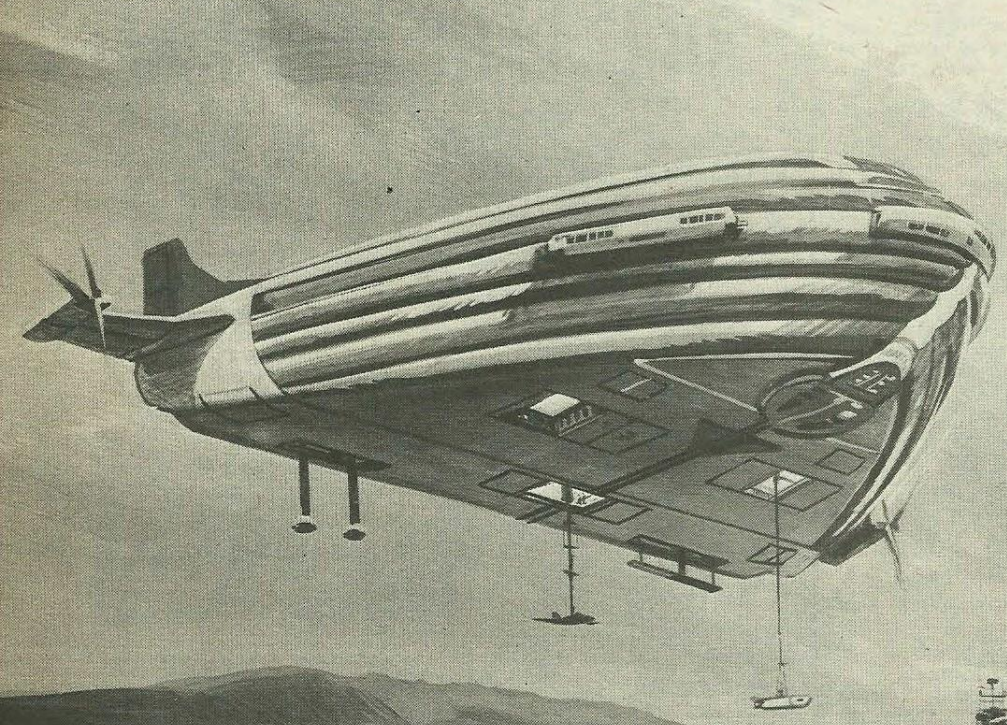
For landing, the vessels will hover over the pad. Hawsers would then be connected. The skyship's engines would be used to produce upward thrust, thus tensioning the cables and enabling the vessel to be winched down on to the pad. Easy and speedy take-offs and landings are in fact among the special advantages of the big disc-shaped transport ships of the skies.

Take-off will be effected in a similar way, the hawsers being held taut as the skyship rises, and then being cast off when a safe height has been reached. A "safe height" will depend upon wind conditions, and in calm weather no hawsers are likely to be needed.

You will find the loading procedure fascinating. The goods to be carried will be pre-packed in containers already dubbed "deacons" — *de*tachable *a*uxiliary *con*tainers. Each of the deacons in turn will be moved on to the pad and the skyship winched down over it, enabling the container to be firmly connected to the craft. In much the same manner empty deacons will be removed to make way for packed ones. Studies of different ways of moving the deacons to and from the loading or unloading sites are at present in progress, but it is expected that the system will be some form of platform on rails.

Bays for loading and unloading the special containers are expected to be provided as near as possible to the point where the skyships load and discharge their cargoes, thus keeping down the amount of time needed for these operations. And around the pad will be many access points where mechanical handling equipment can be used, and which can be easily reached by road and rail transport.

Not only are skyships likely to be flying through the air shortly, but close attention



Equipped with radar and sonar listening devices, a flying ship of this design could carry out a survey of an ocean and record the weather patterns experienced there.

John West, designer of the Skyship.

is being given to the ways in which they could be profitably used. The first bases for these unique flying saucers will be built near motorways. The stations can best be described as small ideally situated inland ports with a ten-acre pad, but with at least a further 20 acres for offices, workshops, fuel storage depots and so on.

Safety precautions aboard skyships are to include dividing them into compartments, like seagoing craft. The way in which fire aboard will be tackled, however, is new. Each compartment will have inlets for helium, and as this gas is inert, fire enveloped by it will go out at once.

Even engine failure would not cause a skyship to crash. These airborne vessels do not rely upon their engines to remain in the air. Their designers say that the loss of one or more engines, at worst, results in a reduction of flying speed. Moreover the engines are to be made fully accessible to the crew, so that faults can be repaired in flight, and a comprehensive range of spare parts, tools, and other equipment can be carried. It may even be possible to carry a complete spare engine, and although there are difficulties associated with this idea, it is being carefully examined.

Many accidents with other forms of aircraft are a result of error or illness on the

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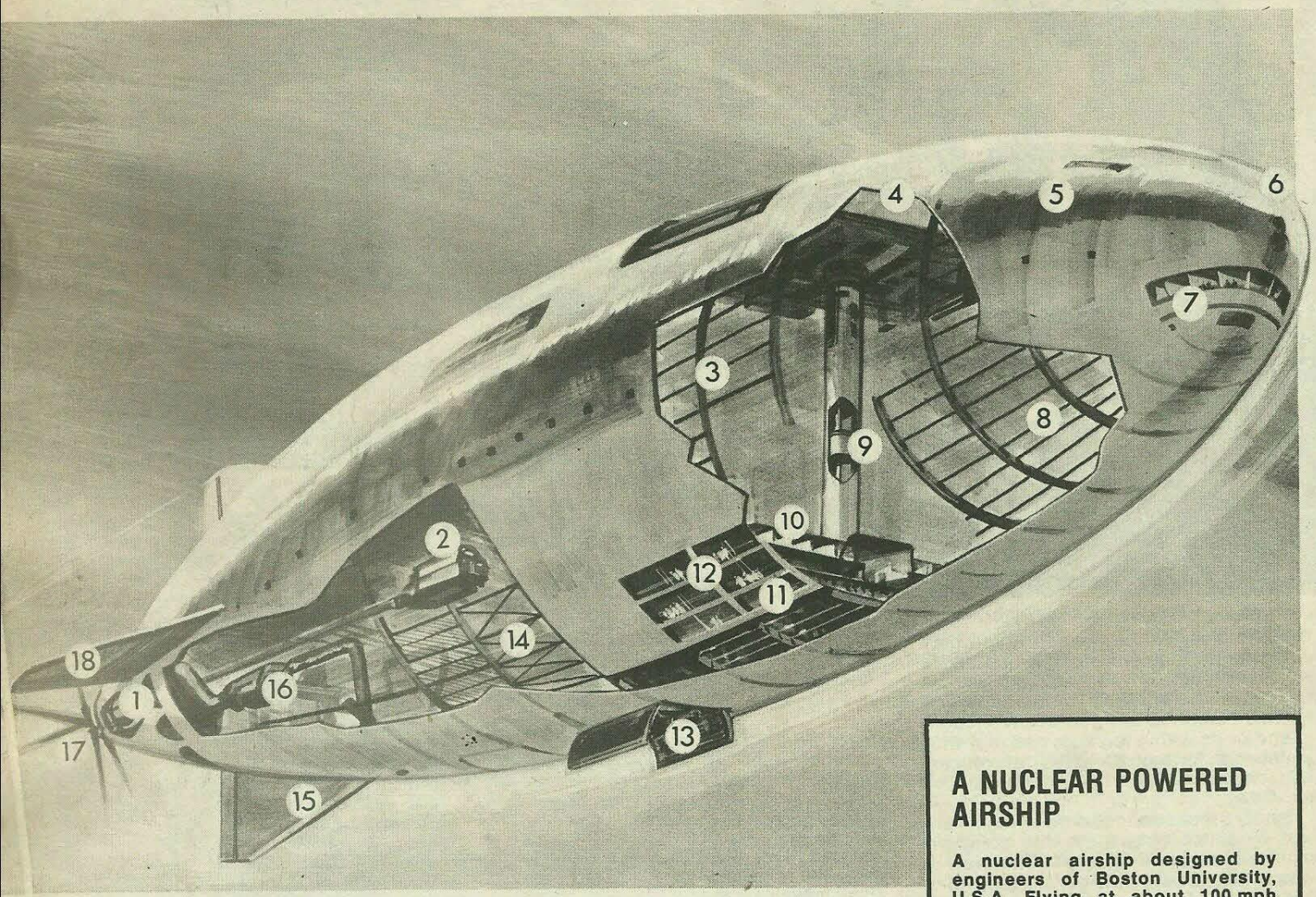
Britain's saucer-shaped skyship (above) has been designed by a team led by Mr. John West. The prototype (right) made its first flight in April this year. It could prove the basis for the full-size vessel (above) which may be as big as a 14-storey building. Below is a cargo airship built to the classic cigar shape.



part of the pilot, but the skyship will be far less likely to suffer in this way. Because it flies at a low speed compared with an aeroplane, there will be much more time to correct an error before its consequences can become disastrous.

Furthermore, the skyship will be controlled from a bridge manned by several members of the crew at the same time, as in the case of a ship. Consequently, it will never be entirely in the hands of one man and, in this respect alone, it is an improvement on other types of aircraft.

The skyship is intended for use as a car and caravan ferry, for it could fly over land as well as over the sea. And it could provide pleasure cruises, again over land routes in addition to flying across the oceans. Another role will be the transporting of engineering plant. The man-made flying saucer could move heavy engineering gear and machinery to distant and very inaccessible places, together with bulk materials and prefabricated site buildings, in days instead of the months often required by other forms of heavy transport.

Military experts, too, are looking for ways in which skyships can be helpful. Nowadays, when the cost of maintaining large numbers of troops and equipment at widespread strategic points is very costly, the alternative is to send such forces quickly from "pools" to places where tension arises.

To be effective, such troops and their equipment must reach the trouble spots quickly. Conventional transport is severely limited in this respect, the soldiers and light equipment only being able to get as far as the nearest airport swiftly, and the heavy equipment taking weeks to arrive by sea. For such movement, the skyship can reduce the time dramatically, from six weeks to one week in many instances. One flying disc can, indeed, carry as much as 105 aeroplanes, including 1,600 men, 70 small vehicles, 14 large vehicles, 60 trailers, and 100 tons of stores!

Navies, too, foresee important uses for skyships. They are ideally suited to anti-submarine warfare, being able to do everything the aeroplane can do in this branch, but with much greater endurance and hitting power, being able to carry a big payload of weapons.

Will the skyship open a chapter in aviation history as influential as the one relating to the development of the hovercraft? Only time will answer that question. But the use of nuclear power for some of these latest aircraft is being forecast.

With such motive power, naval skyships could match the endurance of nuclear powered submarines. Potentially hostile submarines carrying missiles could be under constant surveillance on the high seas.

A NUCLEAR POWERED AIRSHIP

A nuclear airship designed by engineers of Boston University, U.S.A. Flying at about 100 mph (160.9 km/hr), it would have a virtually unlimited range and be able to carry 400 passengers and 150 mini-cars.

KEY TO PICTURE

1. *4,000 hp gas turbine and reduction gears.*
2. *Nuclear reactor.*
3. *Transverse frames.*
4. *Skylighter ballroom.*
5. *Nylon skin.*
6. *Retractable mooring cone.*
7. *Control bridge.*
8. *Forward cargo area.*
9. *Lift shaft.*
10. *Passenger cabins.*
11. *Dining room.*
12. *Promenade decks.*
13. *Doors for shuttle aircraft.*
14. *After cargo area.*
15. *Vertical stabiliser and rudder.*
16. *1,000 hp fan turbine.*
17. *Dual propellers of 60 ft. (18.2 metres) diameter.*
18. *Horizontal stabiliser and elevator.*

CORRECTION

In our article "Danger Over the Alps" (28th June issue) we said that Sheila Van Damm, the rally driver, was the winner of three rallies in 1954. In fact, she won the ladies' prize in these rallies. We are sorry for this mistake.

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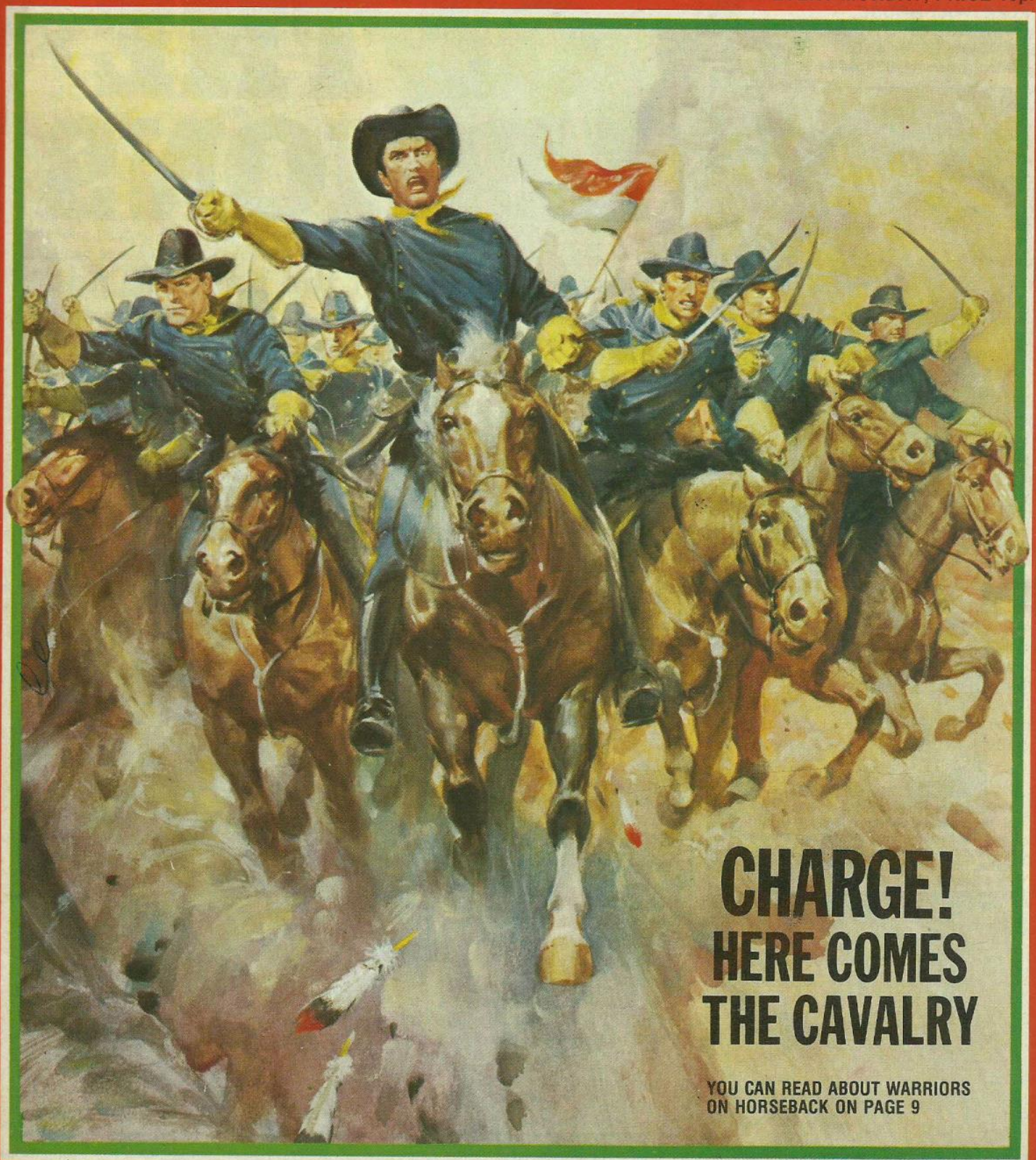

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YOU CAN READ ABOUT WARRIORS ON HORSEBACK ON PAGE 9

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CITY IN THE SEA

Where can we go if we want to escape from our overcrowded land? To the sea, say the Japanese, who have made a three-decker island to show how it can be done.

SEA cities! Man-made islands capable of supporting life by harnessing the riches of the sea after man has exhausted the wealth of the earth. A refuge for land-dwellers in time to come, when shortages caused by wasteful living in cities and towns force people to return to the sea from which some biologists say we came . . .

Far from being a fantasy-dream born in a Jules Verne novel, this is a cold, calculated vision of things to come in the foreseeable future. It has already produced a prototype which floats off the sub-tropical Japanese island of Okinawa as the highlight of Expo '75, the first international fair dedicated to man's relationship with the oceans. The fair has attracted hundreds of thousands of visitors from all over the world and many more will follow before it ends next January.

The gigantic sea city, called Aquapolis, rising more than 60 feet (18 metres) above the sea on huge columns, has astounded visitors who make the trip across the causeway to see it.

Aquapolis is a domed, square island with a string of impressive statistics to justify its proud boast as the world's largest floating building.

It cost about £18 million to put together. It stands 10 storeys high with a 10,000 square yard (8,361 square metres) deck complete with helicopter pad and two main floors beneath. Sixteen columns resting on four massive pontoons support the sea city, which weighs 16,000 tons and is strong enough to withstand the toughest typhoon.

Inside the 16 columns are chains and anchors which can be manipulated to enable the island to move over a 200 yard (182 metre) area and even be elevated to various heights above sea level.

In the "cockpit" or nerve-centre of Aquapolis, a computer co-ordinates all its systems as well as totting up the number of tourists, advising visitors on programmes of entertainment or merely telling anxious mothers where to find their lost children.

Among its elaborate electri-

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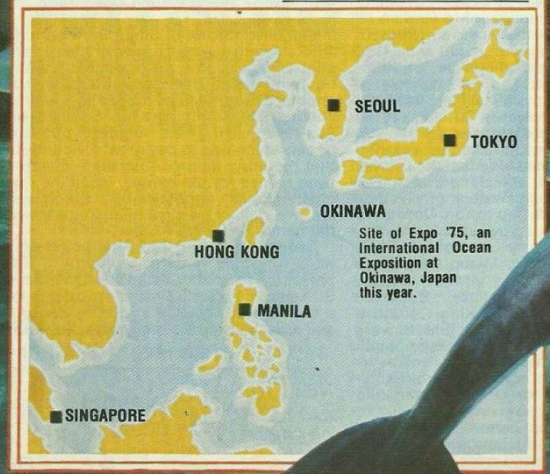
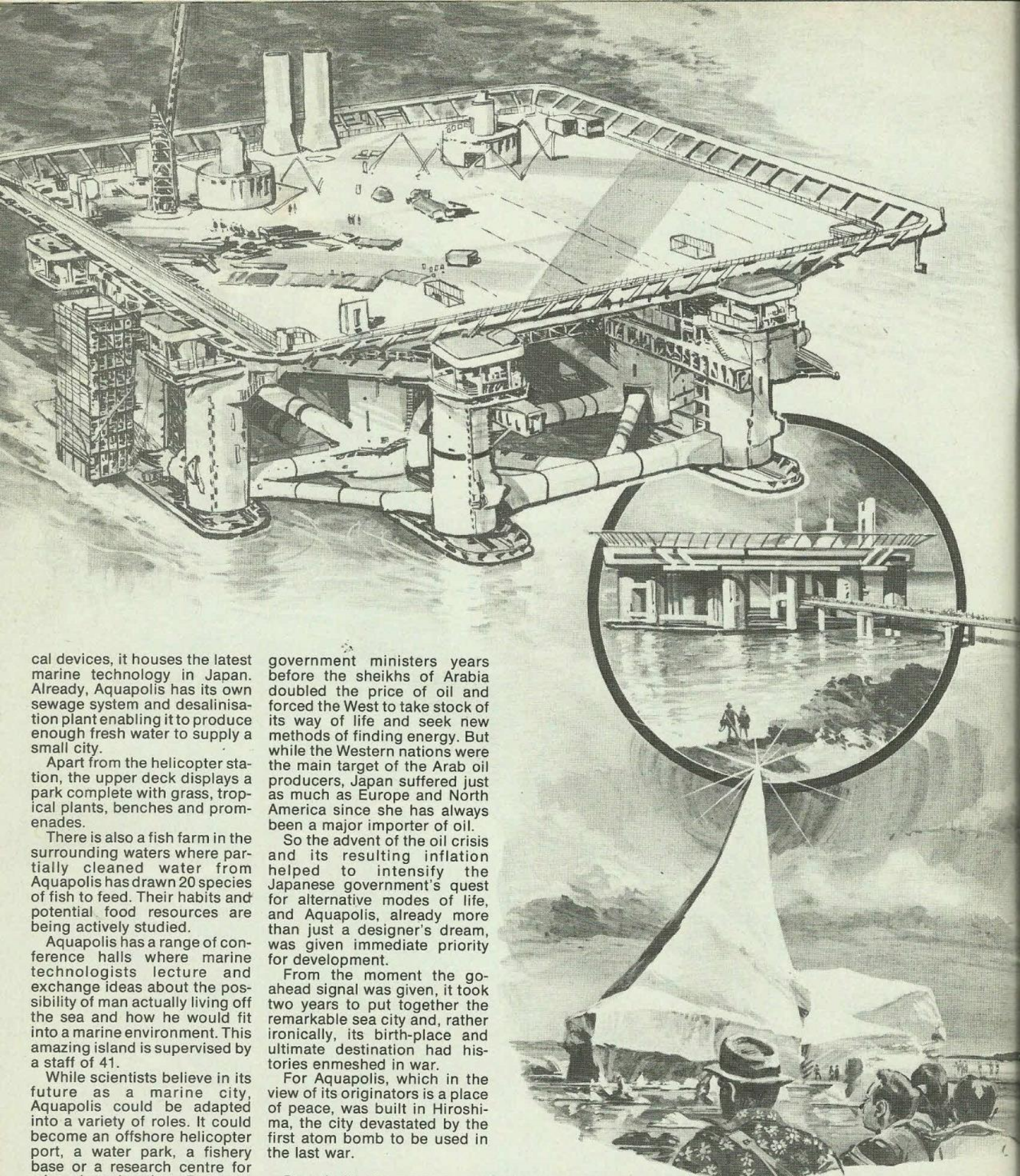


Site of Expo '75, an International Ocean Exposition at Okinawa, Japan this year.

Visitors in a transparent conveyor explore the marine wonders beneath a man-made island on show at an international exhibition at Okinawa, Japan.



cal devices, it houses the latest marine technology in Japan. Already, Aquapolis has its own sewage system and desalinisation plant enabling it to produce enough fresh water to supply a small city.

Apart from the helicopter station, the upper deck displays a park complete with grass, tropical plants, benches and promenades.

There is also a fish farm in the surrounding waters where partially cleaned water from Aquapolis has drawn 20 species of fish to feed. Their habits and potential food resources are being actively studied.

Aquapolis has a range of conference halls where marine technologists lecture and exchange ideas about the possibility of man actually living off the sea and how he would fit into a marine environment. This amazing island is supervised by a staff of 41.

While scientists believe in its future as a marine city, Aquapolis could be adapted into a variety of roles. It could become an offshore helicopter port, a water park, a fishery base or a research centre for mineral exploration. But as a city capable of providing living quarters for families of the future, it has proved it can produce its own solar and thermal energy, fresh water and food from fish and marine life like sea-weed.

The idea of Aquapolis was born in the minds of Japanese government ministers years before the sheikhs of Arabia doubled the price of oil and forced the West to take stock of its way of life and seek new methods of finding energy. But while the Western nations were the main target of the Arab oil producers, Japan suffered just as much as Europe and North America since she has always been a major importer of oil.

So the advent of the oil crisis and its resulting inflation helped to intensify the Japanese government's quest for alternative modes of life, and Aquapolis, already more than just a designer's dream, was given immediate priority for development.

From the moment the go-ahead signal was given, it took two years to put together the remarkable sea city and, rather ironically, its birth-place and ultimate destination had histories enmeshed in war.

For Aquapolis, which in the view of its originators is a place of peace, was built in Hiroshima, the city devastated by the first atom bomb to be used in the last war.

Once built, the problem was where to position Aquapolis to its best advantage. By this time, the organisation of Expo '75 was well under way. And it was here, at Okinawa, the scene of savage fighting in World War Two, that Aquapolis was introduced to the world as an island where men can live at peace.

Planned as a prototype for a city of the future is Aquapolis, shown under construction at the top of the page. It was foreseen as a sea city able to provide homes for people from overpopulated land areas. To enable it to be self-supporting, it was built on three levels. Below the surface of the water is a fish farm where sea creatures are bred.

Housing on the surface provides homes for people displaced from the land. And on the upper level is an agricultural farm. This, with the fishery, would provide employment for the men in the community. In the circular picture you can see Aquapolis moored off one of the beaches at Okinawa, Japan. It was put on show as part of Expo '75, a giant exhibition at which the display above was also featured.

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ON THE COVER . . .

Up to 1,000 passengers could be whisked to their destination in aircraft-type luxury at 700 mph if glider trains like the one on our cover — the idea of Japanese designers — become reality. Powered by turbo-jets, the flying train promises to be just as sensational as another railway flyer of the future, featured in our Speed and Power supplement.

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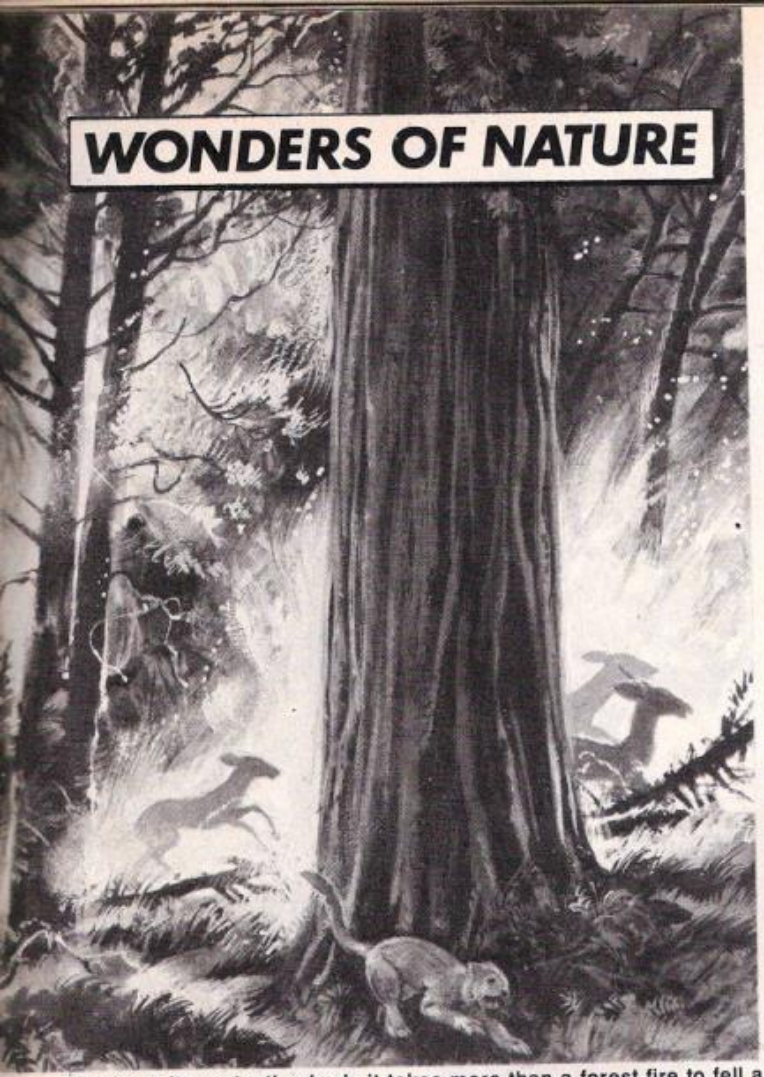
INTO THE UNKNOWN!

SCOURGE OF THE SPANIARDS

Sir Francis Drake

Before Drake sailed from Plymouth the Spanish Ambassador called on Queen Elizabeth to protest at his voyage. She pretended to know nothing about the purpose of Drake's travels.

THAT'S A MIGHTY OLD TREE!



Thanks to its protective bark, it takes more than a forest fire to fell a Sequoia tree.

LED by Indian guides, an American pioneer named Hale Tharp, made his arduous way up the western slopes of California's rugged Sierra Nevada. There were no roads then to make the going easier. But when he reached his goal the sight that met his eyes was rich reward for his efforts. Here at last was the forest of giant trees of which the Indians had spoken with such awe.

That was back in 1859, but the amazing Californian Big Trees have never lost their fascination. Their home is the Sequoia National Park, established in 1890 specially to preserve these wonders of the plant world. We get some idea of the size of the Big Trees when we learn that Tharp, deciding to settle in the forest, made his home in a "log cabin" hollowed out of part of a single trunk.

The genus of trees to which these, and other related species, belong, was given the name *sequoia*, to commemorate the name of the famous Cherokee Indian leader Sequoyah. For sheer bulk, the Big Tree has no rival among living things.

Mightiest of all is the General Sherman tree, named after one of America's Civil War heroes. Over 272 ft (83 m) tall, it has a diameter at its base of about 32 ft (10 m). Twenty men, with arms outstretched, had difficulty in joining hands around it. It would be possible to cut a tunnel through it that would comfortably accommodate the biggest lorry.

It is the overall bulk of the General Sherman that is most impressive. It is estimated that its

A GREAT DEAL CAN HAPPEN DURING THE LIFE OF A REDWOOD

The exact age of a tree can be discovered by the annular rings (formed annually) which spread outwards from its centre. So this section of a giant redwood trunk shows that it was 1370 years old when it was cut down. The drawings show some of the incidents that occurred during its lifetime.

527 The Redwood was just beginning life as Justinian became Emperor of Rome.

1066 The tree was 509 when the Battle of Hastings took place.

1215 Still quite young as Redwoods go, the tree was 658 when the Magna Carta was signed.

1415 The Battle of Agincourt and the tree is now 858 years old.

1666 Its thousandth birthday was well behind it when the Great Fire of London took place.

1805 Still growing, aged 1251, as the fleets of England and France clash at Trafalgar.

The Sequoia is not only the world's biggest tree, it is also the oldest. Indeed, it was already old 3,000 years ago!

total weight is some 2,000 tons — enough wood to make 5,000 million matches.

Huge as the Big Tree is, it grows from a tiny seed. About 6,000 of them weigh only an ounce. Only a small proportion of them germinate, but, with the cones shedding so many seeds, enough young trees are produced to ensure the future of the species.

If you cut through a tree-trunk and count the "growth rings", you can tell how old it is. By this test, the older specimens are of astonishing antiquity. The General Sherman is believed to have begun its life 3,500 years ago.

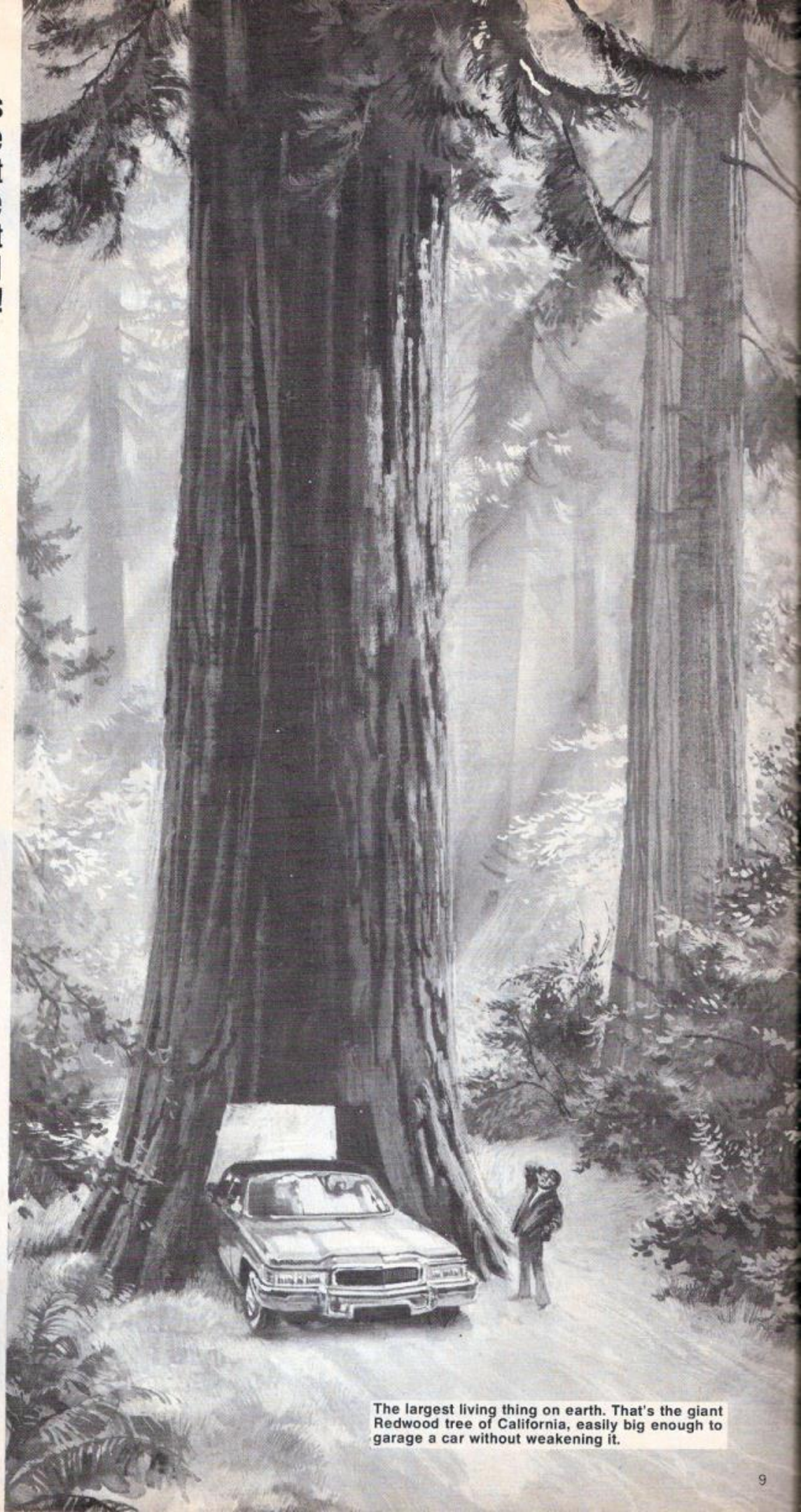
No case is known of a Big Tree dying from disease or old age. One danger to them arises from the fact that they have no deep tap root to anchor them. Instead they have a wide network of shallow roots — sometimes 100 feet (30 metres) in radius. When the soil of the mountain slopes is eroded, their great weight may bring them crashing down.

Against fire, one of the worst threats to conifers, the Big Tree is well protected by a covering of flame-resistant bark, up to 24 inches (31 cm) thick. When fire does reach the wood, it seldom destroys the tree, which grows new wood to cover its scars.

There is no longer any great temptation to fell the Big Tree, as it is now known that its timber is coarse-grained and brittle. But its close relative, the Coast Redwood, is highly valued for its richly-coloured wood, tough and durable as well as beautiful to look at. The Redwood grows in the coastal highlands from Monterey in the south to southern Oregon.

Though less in bulk than the Big Tree, the Redwood is even taller. Many specimens reach a height of more than 300 ft (91 m). It, too, is protected from fire by thick bark, which also excludes harmful insects and fungi.

The number of Redwoods has been much reduced by cutting, but the process is now under stricter control. Timber from the Redwood is excellent for building and other purposes, resisting damp and decay. Fence-posts made from it have been found in good condition after standing for 50 years.



The largest living thing on earth. That's the giant Redwood tree of California, easily big enough to garage a car without weakening it.

THE AUTHOR AND HIS WORKS

THE MAN WHO SAW THE FUTURE

H. G. Wells wrote fiction that could become horrifying fact

CHANCE, as everyone knows, more often than not, takes a hand in shaping our destinies. Certainly this applied to the young boy who lay hidden one Sunday morning beneath some bushes facing a small country church. The doors swung open, and the congregation straggled out.

The boy leapt up and rushed towards a spry figure in Sunday silk — his mother. He flung his arms around her, shouting: "I won't go back, I won't go back!"

The year was 1883, and the boy was Herbert George Wells, who later became a world-famous author, scientist, and prophet. Then he was simply a runaway draper's apprentice who had walked the seventeen miles to his home.

If Mrs. Wells had been in a bad mood and as strict as most Victorian parents, and had sent her runaway son forthwith back to the draper's shop, the world might never have learned of H. G. Wells. And the world would have been that much poorer.

For H. G. Wells, one of the inventors of science fiction, was a man ahead of his time. His ideas created a revolution in world thinking.

THE EIGHTH APPRENTICE

As a small boy, Bertie Wells lived in Bromley, Kent. At fourteen he was apprenticed to a firm of drapers.

His working day began at 7.30 a.m. and ended at 8 p.m. He shared an attic bedroom with seven other apprentices, and took his meals in a gloomy underground room. For a boy like Wells with a burning ambition, much was lacking.

Running away was the first step. At seventeen he became a student teacher with a salary of £20 a year. The headmaster soon realized that he had a remarkable assistant. The young man was entered for a series of examinations.

By hard cramming, Wells passed them all. He gained a scholarship to the Royal College of Science in London, where the great biologist, T. H. Huxley, was one of his teachers. His clothes were threadbare and he lived mainly on dry bread. But for many months science gave him all the nourishment he needed.

For the first time he had access to a great library. He packed his brain with fact and fantasy. He enrolled at the University of London, graduating when he was twenty-two.

At first he tried to teach, but a football accident affected his health. He became a journalist and, between painful illnesses, tried to write a book. At one time, a halfpenny was all the money he owned. He was unable to contact his family because he could not afford the postage.

The man who foretold the future — H. G. Wells.

THE WRITER-PROPHET

In 1895 his first novel, *The Time Machine*, was published. It was the first of many successes.

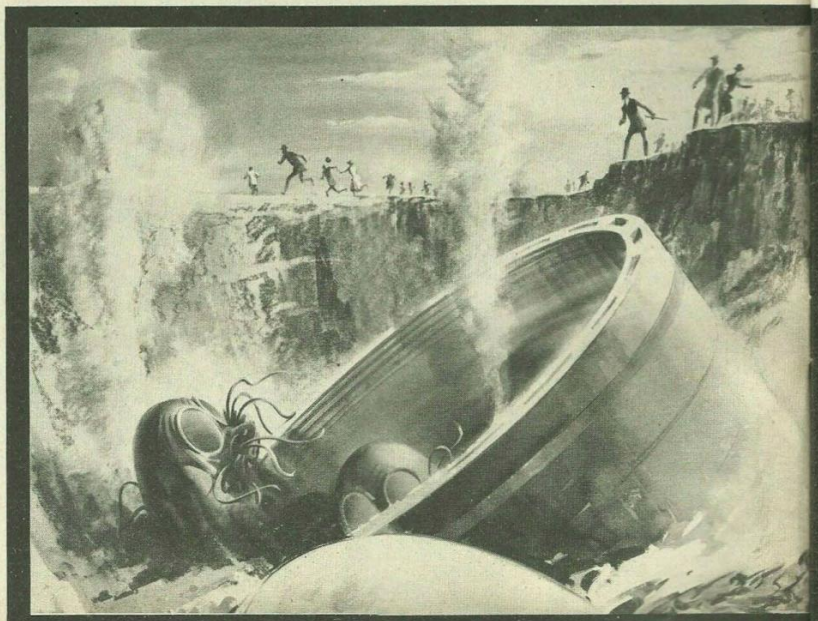
All the scientific fact Wells had absorbed as a student was now transformed into best-selling fiction. But he was also a prophet.

In 1901 he foresaw the possibilities of space travel in *The First Men On The Moon*. In 1914 he wrote *The World Set Free*, which envisaged not only the atomic bomb, but also a world parliament, not unlike U.N. by 1950.

In a series of magnificent books — such as *The Outline of History* and *The Science of Life* — he tried to pass on to his readers an awareness of themselves and their world, which he hoped would prevent them from destroying it.

He died in 1946, and now, as the rockets continue to soar into outer space, beyond the moon even, there seems little doubt that Herbert George Wells was a genius who knew better than most of us the shape of things to come.

NEXT WEEK: HE MADE A KINGDOM WITH HIS PEN



AN EXTRACT FROM . . .

THE WAR OF THE WORLDS

IT was from Mars, the red planet, for centuries the star of war, that the invasion came.

I did not see the glow as the first Martian cylinder landed on the common near Woking. The few who did thought it was a falling star — a meteorite.

People turned in their beds and went back to sleep.

The world seemed so safe — and so tranquil.

Next morning an astronomer, searching for the supposed meteorite, came across the red-hot cylinder, half-buried in the sand, and heard the first faint stirrings inside it.

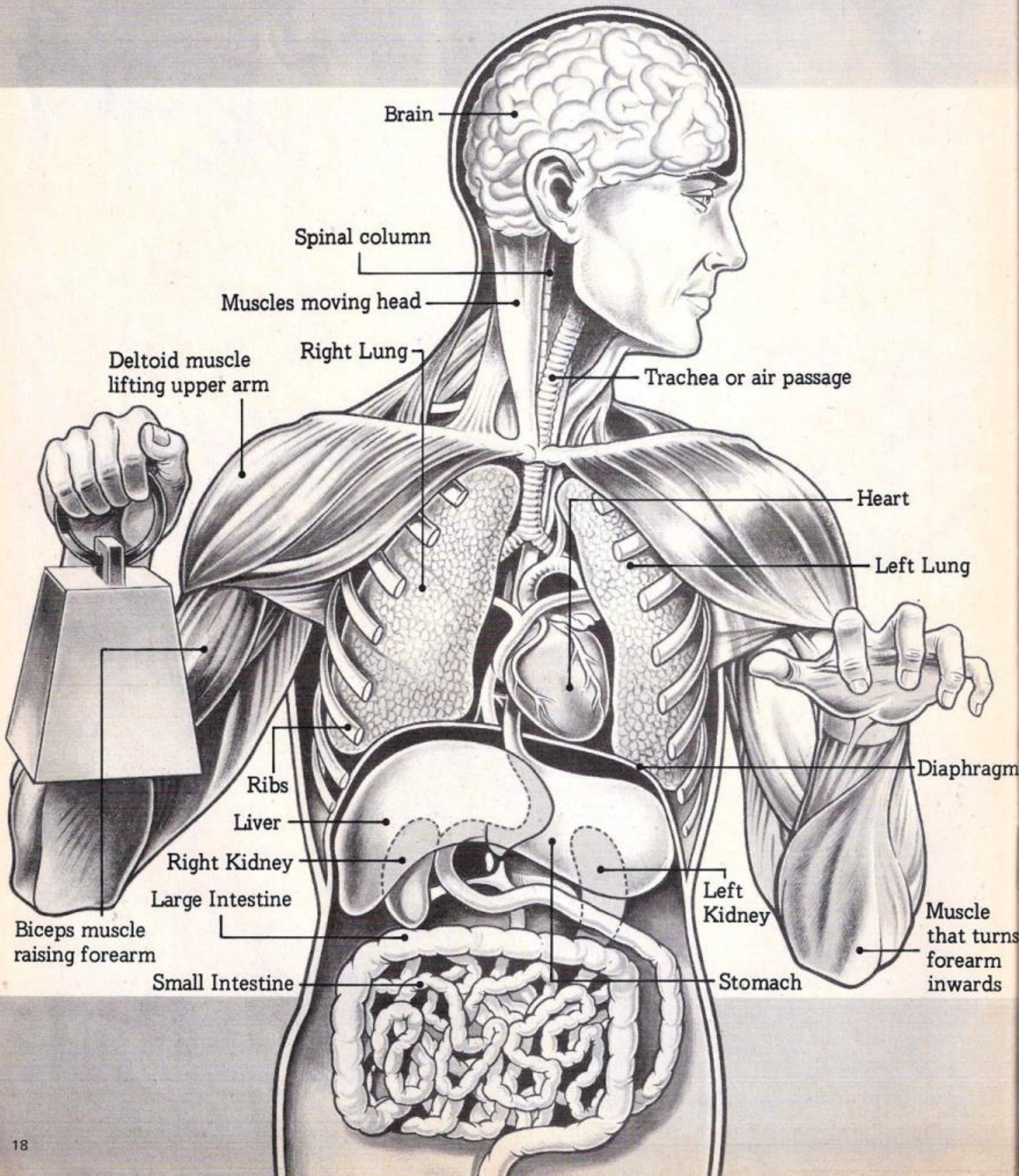
By evening a crowd had gathered. Then as they sipped their ginger beer and crunched their green apples, the end of the cylinder began to unscrew — from the inside. The lid fell with a ringing sound on to the gravel.

The Martians had arrived.

The men from Mars had landed on Earth and assembled their great walking tripods. Now they were destroying everything in their path with invisible heat rays — a deadly weapon unknown until the War of the Worlds.

A new series in which Look and Learn examines the most complex piece of mechanism in the world . . .

THE HUMAN MACHINE

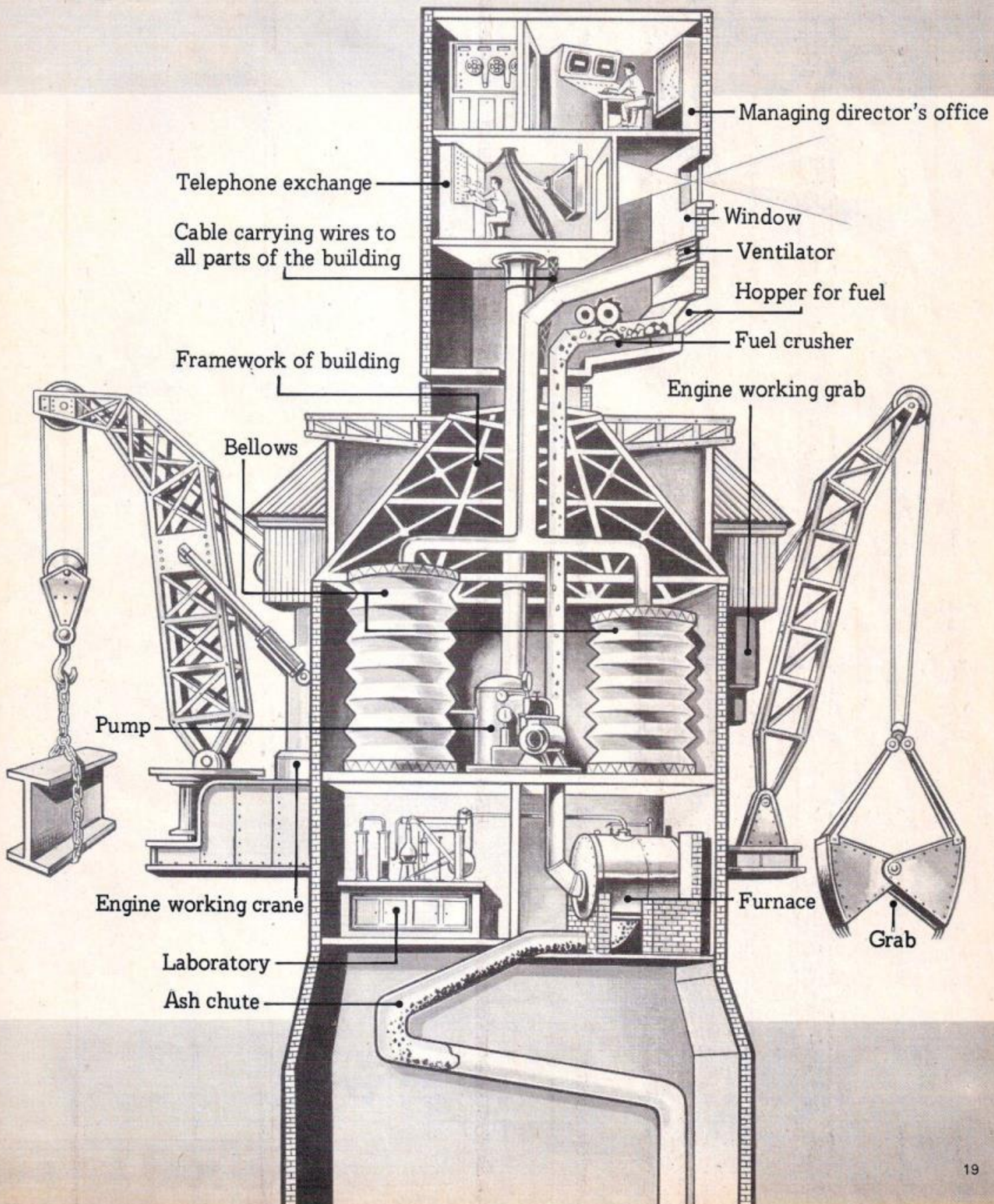


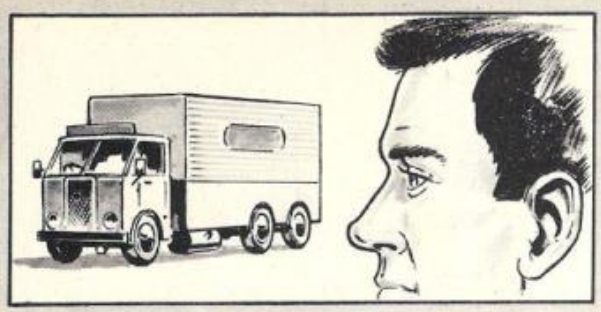
IF engineers said that they could build a machine, such as a motor car, a locomotive or an aircraft, which would keep running efficiently for scores of years without ever stopping, no one would believe them. If the engineers went even further and said that their machine would be fitted with a telephone exchange, a telegraph system, a complicated filtering plant and crane and grabs, people would just laugh.

People would laugh louder still if the engineers went on to claim that the wonder machine would start as a very small one, complete in every way, and then get bigger and bigger as the years passed. The engineers might then go on to tell us that as the parts of their wonder machine wore out, the machine itself would replace them.

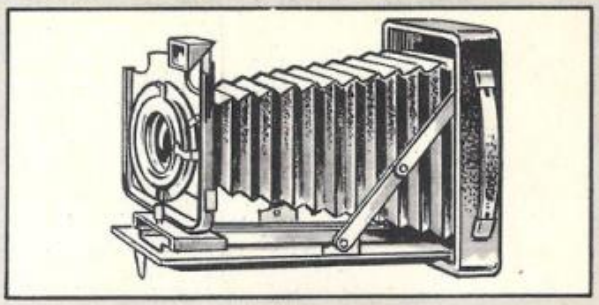
It all sounds like something invented for science fiction. But there are, in fact, thousands of millions of these wonder machines at work all over the world. And they have been in existence for hundreds of thousands of years.

CONTINUED ON NEXT PAGE ▶

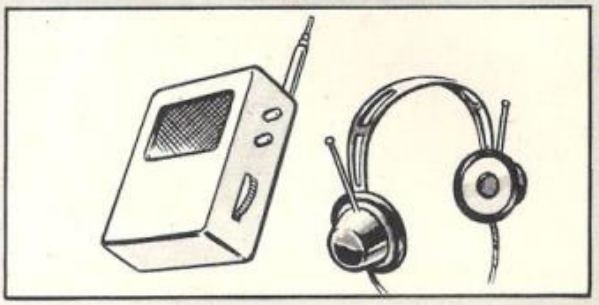




The eyes of the man on the left see the passing lorry and his brain registers it as a picture. In much the same way, the camera lens "sees" an object and records it as a picture on film.



The ears of the girl on the left act as microphones to pick up the sound vibrations from the record player and her brain turns the vibrations into speech or music. The microphone on the right is a mechanical ear linked to the headphones which turn the electrical impulses picked up by the radio receiver into speech or music.



Incredible as it may seem, your body is not so much a single machine as a collection of machines keeping an elaborate factory in action

You yourself are one of these machines, for the machine is your own body.

The human body is the most amazing thing in all the world. It is something more than a machine. Not only does it have its own power station and a whole network of communications keeping all the parts in contact with each other, but it is equipped with pumps, microphones, cameras, broadcasting station and a host of other devices.

Your body is more efficient than any machine built by engineers. As long as it is not damaged by accident or bad usage, it goes on doing its work of keeping you alive day after day and year after year.

The drawing on page 18 shows you the main pieces of equipment inside your body. They do not look at all like complicated pieces of machinery.

Now look at the picture on page 19. All the organs shown in the first picture have been replaced by everyday mechanisms and equipment which do exactly the same jobs as your heart, lungs, kidneys, muscles, stomach, brain and limbs.

In fact, your body is not so much a single machine as a collection of machines keeping an elaborate factory in action.

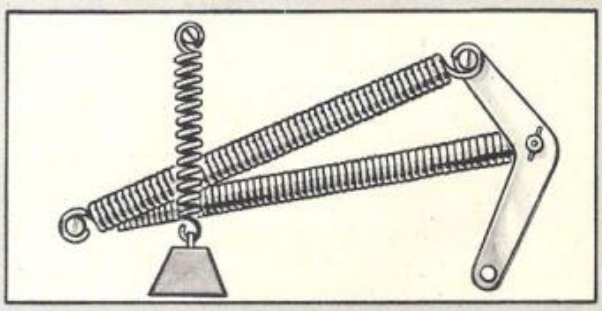
At the top of the factory is the managing director's office — the brain. From here messages are sent through a telephone exchange telling the various departments what they have to do to keep the factory running smoothly.

Like your body, the factory must have fresh air. This is done with bellows which perform the function of the human lungs. Pumps circulate liquids throughout the factory just as your heart circulates your blood.

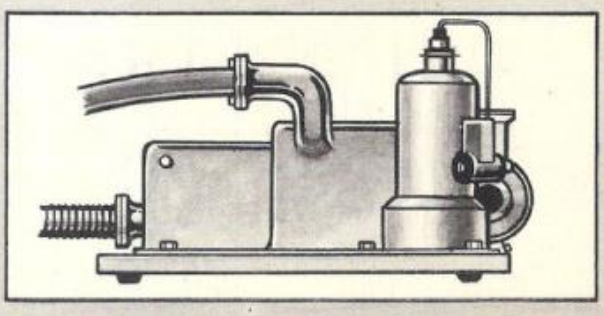
The factory has a furnace which burns the fuel that releases its energy to keep the factory's machines, such as cranes and grabs, working. In the same way, the food we take is crushed by the teeth and passed to the stomach, where it goes through various chemical processes which turn it into the energy that enables us to move our limbs and head and perform many other actions every day. Most of us know very little about the many wonderful bits of machinery which make up our body or how they work. So during the next few weeks we shall be explaining just how the human machine keeps on working.

NEXT WEEK:
THE CAMERA IN YOUR HEAD

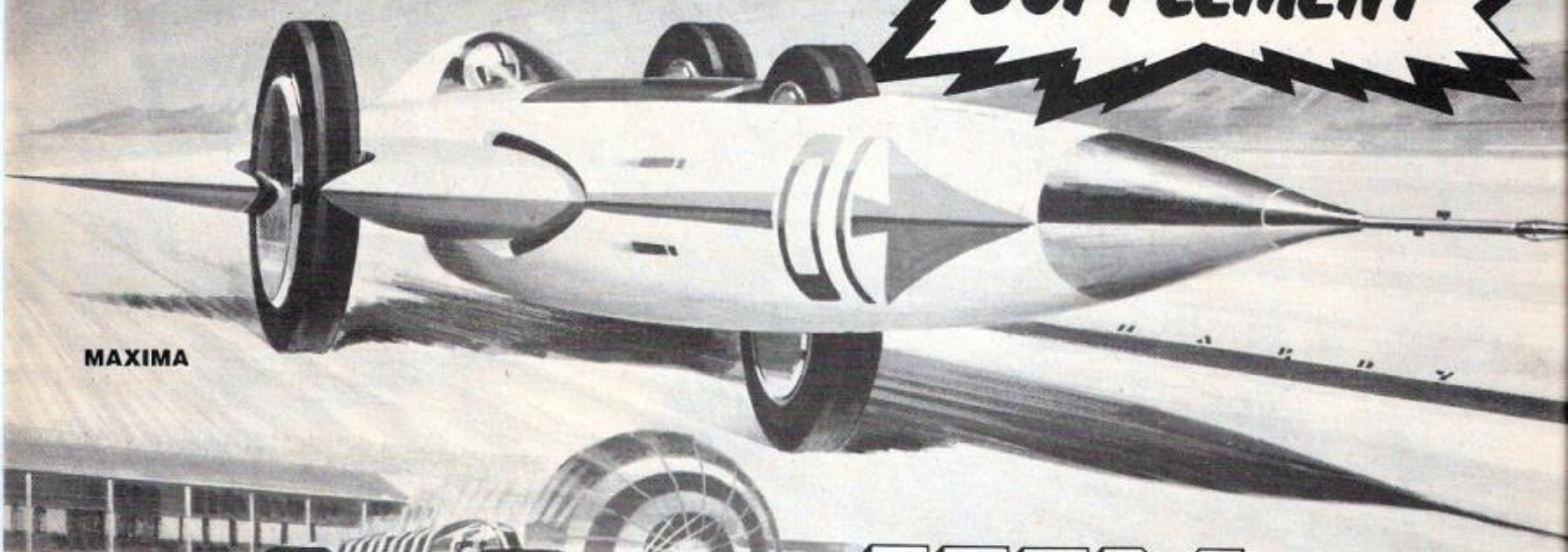
The workmen on the left digging the ground and wheeling away bricks are using bones and muscles which work in much the same way as the assembly of springs, weight and lever on the right.



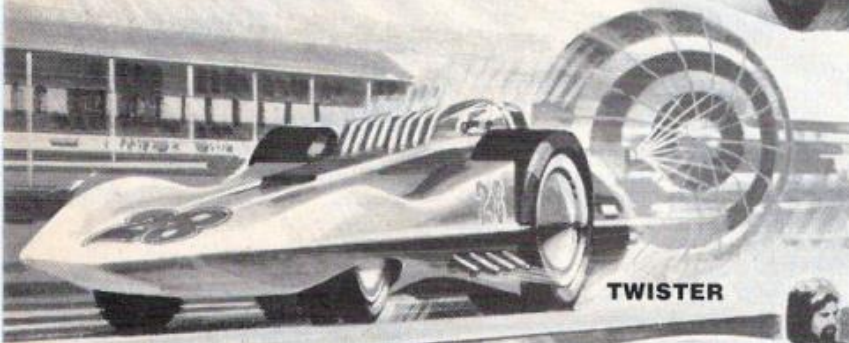
Mountaineers scaling great heights need extra oxygen to be carried in the blood and through the lungs; therefore breathing is faster and the blood flows quicker in the veins and arteries. This is done by the heart beating faster. In this way the human heart is like the mechanical pump on the right, which can be speeded up when more work has to be done.



Speed & Power SUPPLEMENT



MAXIMA

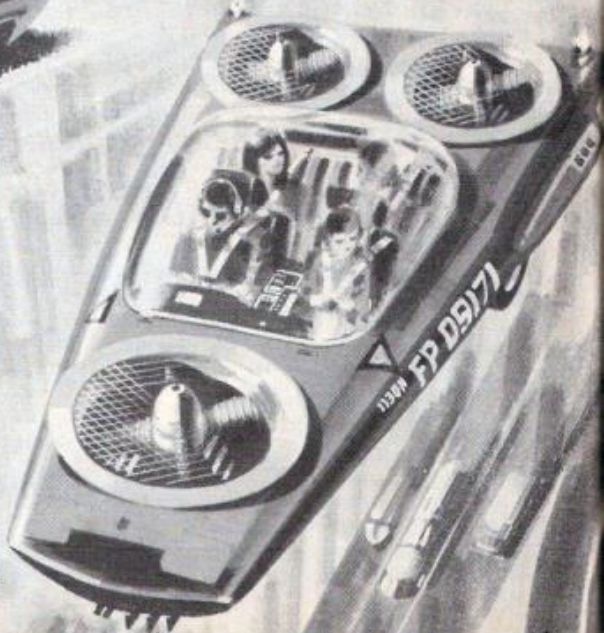


TWISTER

FORDS FOR THE FUTURE

SEATTLE-ITE

Dreams of swishing silently down a super-highway at over 150 mph in a car with an auto-pilot taking care of the driving and navigation seems a far cry from today's traffic-clogged, speed-restricted roads. But even now car designers are looking towards 2000 AD when new power units could replace the petrol engine and electronics will take the manual and mental effort out of driving. Read about these designs and developments overleaf . . .



VOLANTE

FORDS FOR THE FUTURE

Continued from previous page

IN A recent exercise in creative imagination, the Project Design Office of the Ford Motor Company in America produced the advanced and spectacular machines illustrated on the previous page.

Two of them in particular would pack plenty of speed and power. The *Maxima* is a delta-shaped model intended for jet-thrust propulsion and is designed to operate at supersonic speeds.

The Ford team say that an automatic course correction system linked to the jet engine would eliminate the need for a huge, drag-producing rudder. The needle nose of the model was designed to act as a Pitot tube (as used on aircraft) for accurate indications of air speed and to prevent violent shock wave formations.

The proposed function of the *Maxima* would be to serve as a test vehicle for car components at extremely high speeds. It also looks like a potential Land Speed Record machine.

Ford call the *Twister* a "dream dragster." In this design the driver's cockpit is fully enclosed and contains a semi-reclining contour couch that could withstand extreme G-loads.

This handsome hot-rod would be powered by dual engines driving through a common gearbox, an arrangement which could produce as much as 950 bhp. The cockpit canopy is hinged at the front for easy entry and exit. The *Twister* would also feature 16 engine exhausts (one for each cylinder), and a pod at the rear containing a braking parachute eight feet (2 metres) in diameter.

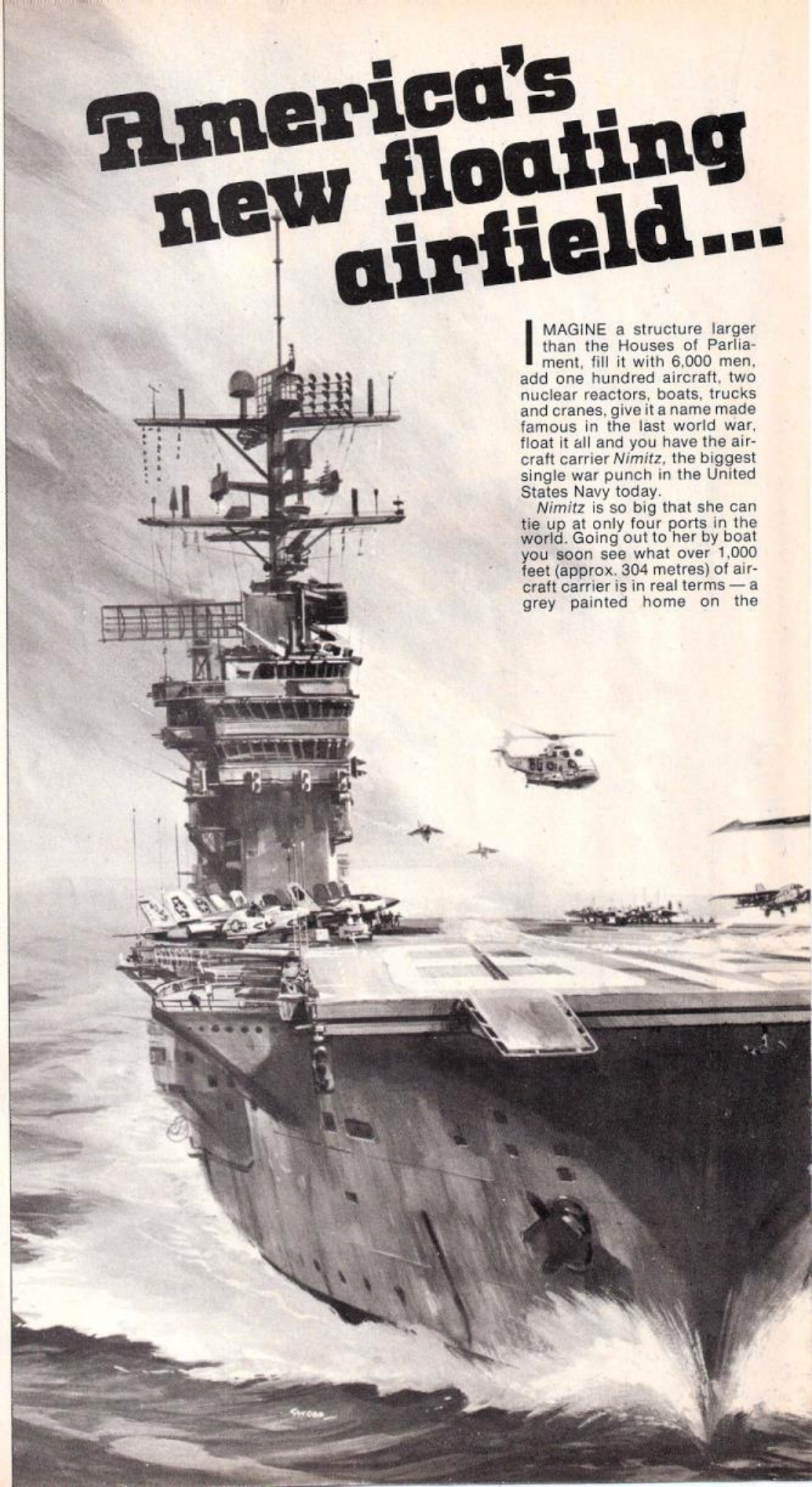
The *Volante* is a sleek aero-car, a saloon-sized vehicle capable of operating both in the air and on the ground. This flying ability would be made possible by the use of the hovercraft ducted fan principle.

A more conventional car is the six-wheeled *Seattle-ite XXI*, but this also boasts a number of remarkable devices. The four front-drive wheels are said to greatly improve steering, grip and braking efficiency. Interior fittings include a computer that keeps the driver informed of traffic and weather conditions and a viewing screen which shows information such as estimated time, and an automatically rolling road map to pin-point the position of the vehicle in relation to a map. So there's little chance of getting lost in a car like this!

America's new floating airfield...

IMAGINE a structure larger than the Houses of Parliament, fill it with 6,000 men, add one hundred aircraft, two nuclear reactors, boats, trucks and cranes, give it a name made famous in the last world war, float it all and you have the aircraft carrier *Nimitz*, the biggest single war punch in the United States Navy today.

Nimitz is so big that she can tie up at only four ports in the world. Going out to her by boat you soon see what over 1,000 feet (approx. 304 metres) of aircraft carrier is in real terms — a grey painted home on the



INSIDE STORY

Take a look at this railway flyer of the future!

CANADIAN SUPERTRAINS

Powerful expresses charging along at 120 mph and tough double-deck city trains — that's what the Canadians have in store for tomorrow's railways.

CANADA is a land of wide open spaces and its trains cover great distances. A new generation of trains is now being developed for both superfast travel and high-density community work.

The first, and most dramatic, is a fantastic speedster called *Futura*. This is a luxurious express designed by Hawker Siddeley, the builders of many of today's jet aircraft, and will be capable of speeds of up to 120 mph.

Futura is a very rugged looking train — the cabs are fitted with heavy duty collision posts for crew protection — but the main bodywork is shining aluminium. When the train eventually takes to the rails, a massive diesel engine of 3,000 horse-power will heave the 15-car train along at speeds over the 100 mph mark.

Below: A sleek and powerful *Futura* train in action on a Canadian railroad. These trains are being developed by Hawker Siddeley in Canada and will be powered by a mighty 3,000 horse-power diesel engine. This will give the train a top speed of 120 mph. Several locomotives could be coupled up together for long high-power journeys.

KEY TO DRAWINGS OF FUTURA TRAIN

1 – Heavy-duty anti-collision nose. 2 – Crew toilet facilities. 3 – Driver's controls. 4 – Second man's position and cooking facilities. 5 – Fuel tank underneath; capacity for 900 miles of travel. 6 – 3,000 horse-power diesel engine. 7 – Electric generator for heating, lighting and air-conditioning. 8 – Baggage compartment. 9 – Restaurant. 10 – Galley. bar. 11 – Cafe and lounge. 12 – Passengers' washroom. 13 – De luxe coach.

The driver is supplied with a complicated display of controls, but works in armchair comfort. He even has a refrigerator, water cooler and hot plate for travelling meals!

Passenger comfort is even better for the 850 or so who will ride in *Futura*. Apart from conveniences like air conditioning and automatic electric doors, there will be a coffee shop, restaurant and lounge.

These trains can be powered in several ways — pulled by a single locomotive, pulled by several locos hooked up in multiple, or with a loco at each end of the train, one pushing and one pulling.

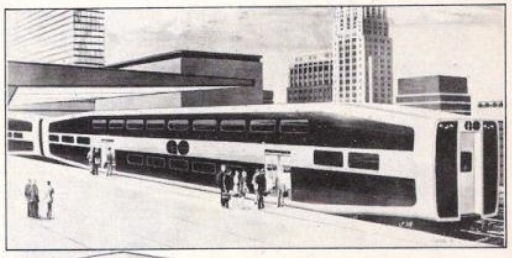
The attractive streamlined *Futura* is certainly a handsome train and combines the assets of speed and luxury.

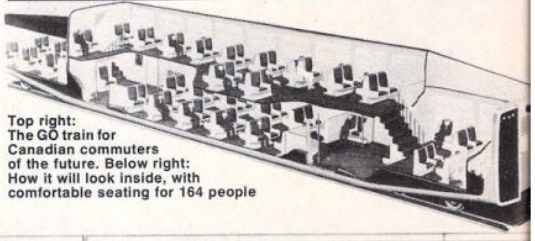
Another new train from Hawker Siddeley in Canada has not been designed for speed, but is a futuristic development of today's commuter trains. The main idea of the trains is to pack as many people into as luxurious accommodation as possible, and this has been done by making *double-deck* vehicles!

An amazing 164 passengers can be seated in each self-contained car, which is 85 feet long — only just over the length of two London buses. The cars will be linked up in multiple for busy rush hour work.

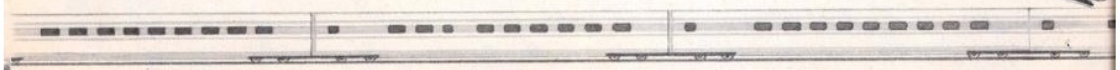
The train has been designed for Ontario's "GO" transport system, which has the difficult job of ferrying thousands of the city's workers around. The new double-deck cars can be powered by diesel, electric or gas turbine engines.

With new trains like these, Canada is certainly moving in the right direction.





Top right: The GO train for Canadian commuters of the future. Below right: How it will look inside, with comfortable seating for 164 people



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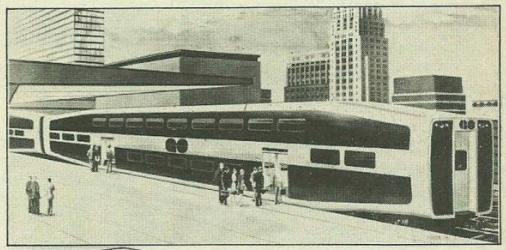

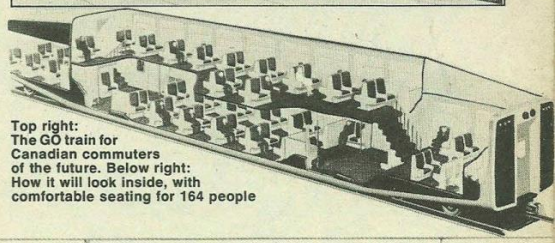

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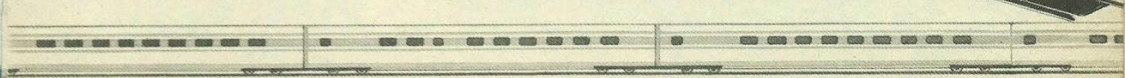


If you go for a walk on the moon...

The explorer on Earth travels light because the atmosphere nourishes and protects his body. But the explorer in space has to take that atmosphere with him – strapped to his back!

IF you go for a walk on the moon you would be wearing the most expensive suit on Earth! For that protective suit — often called a man-powered spacecraft — could cost about £100,000. And, with the vital back-pack, it could weigh almost half-a-hundredweight.

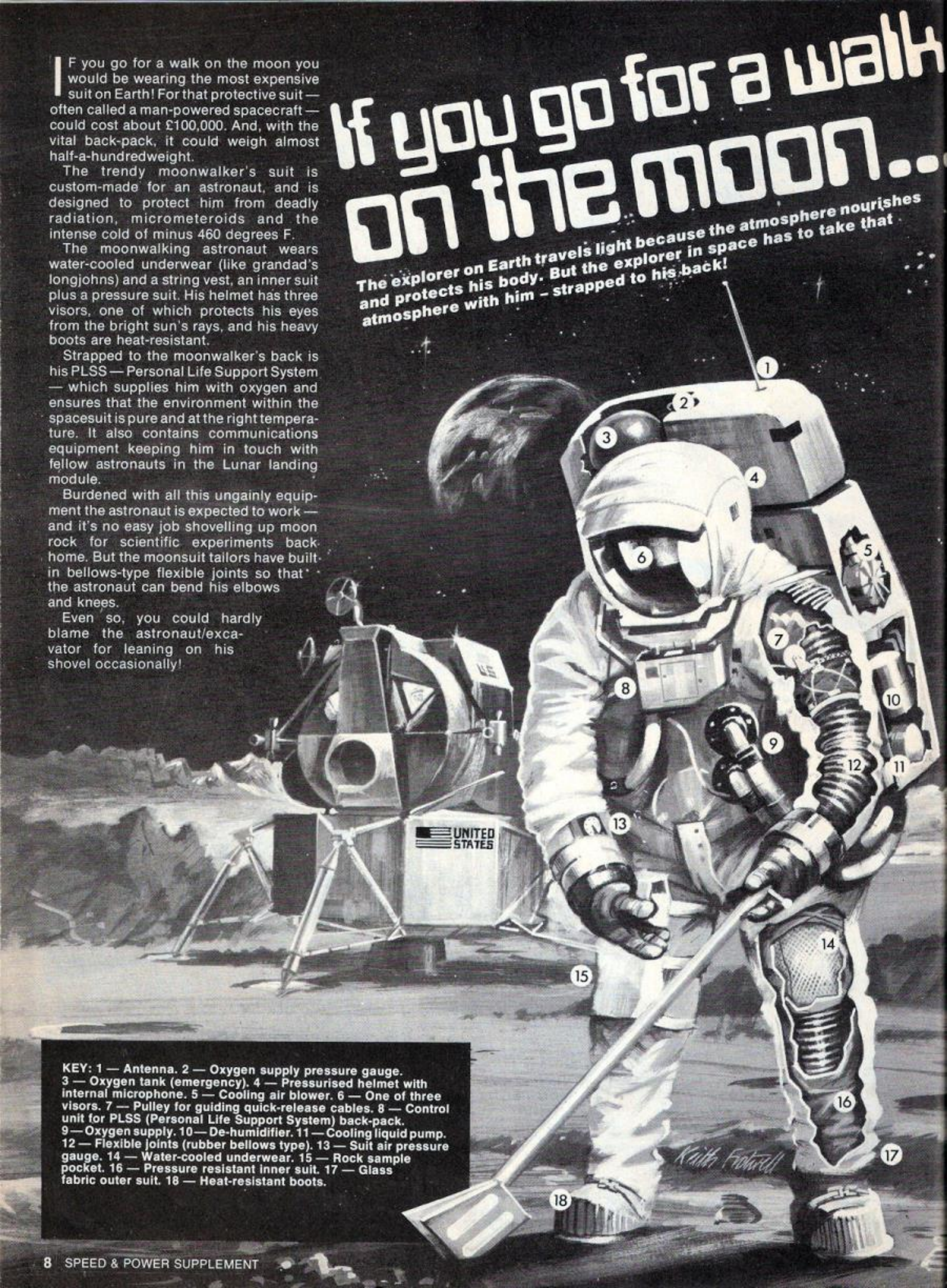
The trendy moonwalker's suit is custom-made for an astronaut, and is designed to protect him from deadly radiation, micrometeroids and the intense cold of minus 460 degrees F.

The moonwalking astronaut wears water-cooled underwear (like grandad's longjohns) and a string vest, an inner suit plus a pressure suit. His helmet has three visors, one of which protects his eyes from the bright sun's rays, and his heavy boots are heat-resistant.

Strapped to the moonwalker's back is his PLSS — Personal Life Support System — which supplies him with oxygen and ensures that the environment within the spacesuit is pure and at the right temperature. It also contains communications equipment keeping him in touch with fellow astronauts in the Lunar landing module.

Burdened with all this ungainly equipment the astronaut is expected to work — and it's no easy job shovelling up moon rock for scientific experiments back home. But the moonsuit tailors have built in bellows-type flexible joints so that the astronaut can bend his elbows and knees.

Even so, you could hardly blame the astronaut/excavator for leaning on his shovel occasionally!



KEY: 1 — Antenna. 2 — Oxygen supply pressure gauge. 3 — Oxygen tank (emergency). 4 — Pressurised helmet with internal microphone. 5 — Cooling air blower. 6 — One of three visors. 7 — Pulley for guiding quick-release cables. 8 — Control unit for PLSS (Personal Life Support System) back-pack. 9 — Oxygen supply. 10 — De-humidifier. 11 — Cooling liquid pump. 12 — Flexible joints (rubber bellows type). 13 — Suit air pressure gauge. 14 — Water-cooled underwear. 15 — Rock sample pocket. 16 — Pressure resistant inner suit. 17 — Glass fabric outer suit. 18 — Heat-resistant boots.

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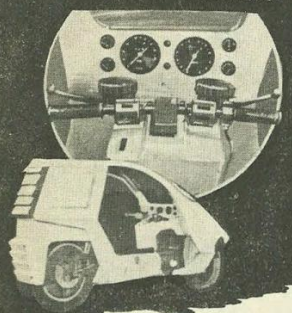
FROM MOTORWAYS TO SKYWAYS

Will the cars of the future take to the air?
See Supplement

QUASAR

Weather-beater Bike

Continued from previous page



Top: Dash panel has a full array of instruments. Above: Body has built-in roll-bar for safety and roomy rear luggage locker.

semi-bodied beauty called the Quasar.

The engine is the well-tried light alloy unit which powers the Reliant Robin three-wheeler car. Mated to a four speed gearbox this drives the Quasar's rear wheel through a shaft and crownwheel and pinion. A more efficient and less troublesome arrangement than a chain drive.

The tubular frame has a radiator mounted across its front and because the rider (driver?) is positioned some way back from the front wheel, a linkage connects the forks to a set of slave handlebars.

Five-spoke alloy wheels are standard and the clutch, brake, throttle and gearchange controls are like those on a normal bike. The dash panel contains a speedometer, rev-counter, ammeter and gauges for fuel, oil pressure and water temperature.

The body is shaped to give downward air pressure at speed and below the tinted windshield are two wipers, one for the screen and the other for the flared-in headlights, both of which are kept clear by a heater/demister unit.

With over 32 bhp on tap and the smooth aerodynamic shape of the body, the top speed is estimated at just over 100 mph (160 kmh.). A gallon of petrol lasts 100 miles at 50 mph (80 kmh.) which, added to the smooth quietness of the machine, plus the not-unreasonable price tag of £1,800, makes the Quasar a real star performer and trendsetter for motorcycling in the late 1970s.

Racetrack Evolution

Racing cars have become 180 mph road-hugging projectiles. What will they be like ten years from now?

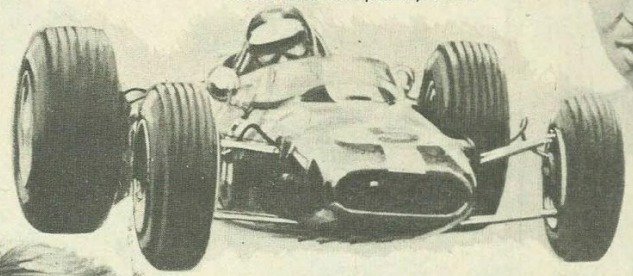
"OF COURSE, twenty years ago the drivers were gentlemen and they needed real skill, nerve and strength to handle the cars. Today's Formula One stars are just a lot of over-paid playboys!" That's the sort of remark you might hear from an older diehard motor racing spectator. But were Fangio, Moss or Clark any better drivers than the current super heroes? Probably not, but certainly the cars are now very different!

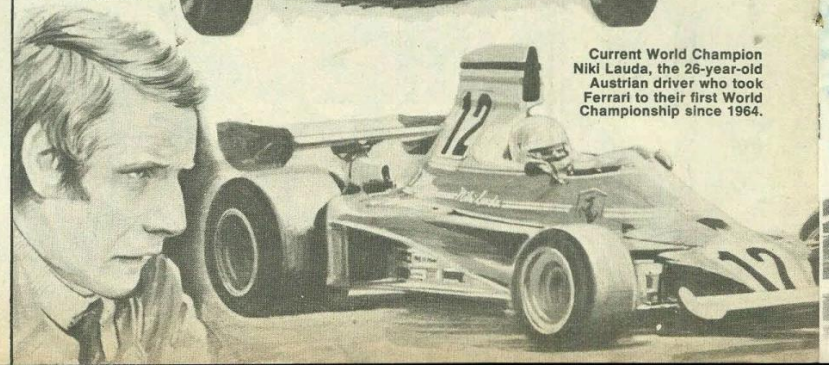
The big, front-engined Mercedes in which Juan Manuel Fangio won the 1955 World Championship looks almost antique compared with the ultra-low, winged projectiles raced these days.

The cars were heavy, the suspension crude and the skinny tyres didn't grip half as well as modern 17-inch (approx. 431 mm.) wide super-slicks.

The Maestro — Juan Manuel Fangio winner of five World Drivers Championships and the front-engined Mercedes in which he won the 1955 series of Grand Prix races.

Star of the late 1960s, Jim Clark who beat Fangio with 25 Grand Prix wins and perhaps the greatest of GP drivers before he tragically lost his life in 1968 in a non-championship event.





Current World Champion Niki Lauda, the 26-year-old Austrian driver who took Ferrari to their first World Championship since 1964.

Ten years later, in 1965, the cars and the speeds they reached had changed dramatically, but the skills and judgment needed to drive right on the limit were just the same. Jim Clark drove a Lotus to six victories in nine races in 1965 to clinch the Championship. Engines were then rear-mounted and the chassis of the Lotus was little larger than a bathtub with a semi-reclining driving position. Spindly but road-hugging suspension carried tyres which, oddly enough, were little wider than those Fangio drove on.

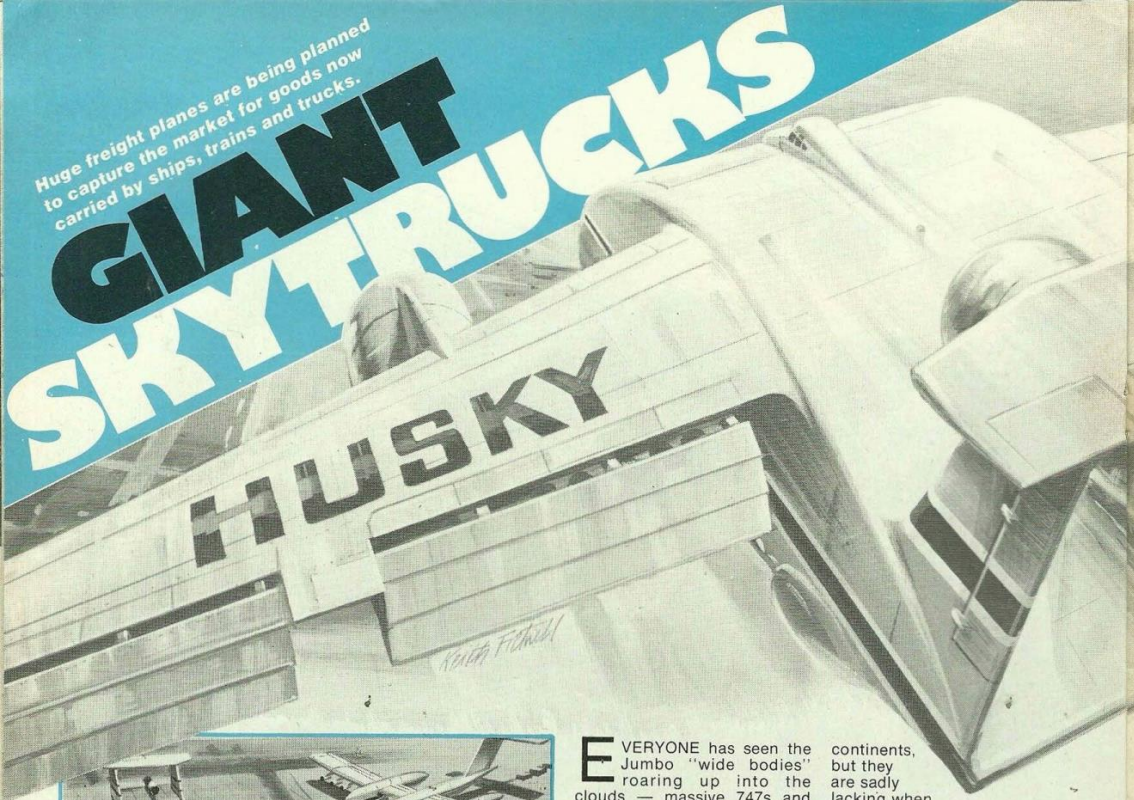
Niki Lauda, the 26-year-old Austrian driver, is this year's Champion which he won on a low, wide-bodied, fat-tyred, aerofoiled Ferrari. Safety regulations require the car to be fitted with a built-in fire extinguishing system and fuel tanks that will not spill petrol if they are damaged in a crash. The chassis is of non-deformable structure to protect the driver and he wears flameproof underwear, overalls and a full-face helmet fed by an air-support system in case of fire.

What will the cars, tracks and drivers of 1985 be like? We can only guess at Formula One developments. Our artist has drawn his impression of the motor race 10 years from now but, whatever the technical developments, we can be pretty sure the skills, courage and coolness of the drivers will still be there.

CAR OF THE FUTURE?
Key: (1) Negative lift fans to increase the car's downward thrust. (2) Twin-front wheels to reduce air resistance of wide section slicks. (3) Ejector pod triggered off by violent "out-of control" gyrations of the car. (4) Aerial for two-way radio communications with the pits. (5) Side-mounted cooling radiators. (6) Inflatable crash barrier to absorb shock of collisions. (7) Electronic control for start and finish of race. (8) Helicopter carrying television monitoring equipment and fire and rescue equipment.

Huge freight planes are being planned to capture the market for goods now carried by ships, trains and trucks.

GIANT SKY-TRUCKS



EVERYONE has seen the Jumbo "wide bodies" roaring up into the clouds — massive 747s and DC-10s, crammed with hundreds of passengers and cargo. But they are real "skinnies" compared with the giant cargo planes some American designers want to build.

Surely the Jumbos are big enough? Why would we want even bigger planes? Well, the ones we have now are ideal for carrying passengers across the great oceans or over continents, but they are sadly lacking when it comes to cargo.

Today, millions of tons of cargo are moved every year by air. Most of it travels in regular passenger aircraft, loaded into rather cramped freight holds under the floor. Some travel in containers or on pallets above the floor in quick-change aircraft carrying a mix of passengers and cargo on the main deck. Some travel in all-cargo aircraft, but these are nearly always the same sort of aircraft as those used to carry passengers. Some of the cargo is military equipment, such as tanks and guns, and this is transported in specially designed "logistic" aircraft capable of being quickly loaded with very large or heavy items (which, if necessary, can be parachuted out of the back).

Left: The new freighters would have a huge carrying capacity but would be smaller overall than today's Jumbos. They could use the airports which now take the 747s and would be more acceptable than another of Boeing's proposals, a giant oil carrier (at the top of the picture).

Right: In times of conflict today's passenger and freight planes have to supply battle-front troops. Here the Husky/Boeing proposal would be even better than the specially designed C-5A Galaxy as it would have more carrying capacity.

What the world really needs — say many experts — is a plane specially designed to take large, bulky, everyday cargo. Such an aircraft could revolutionise the way freight is transported.

At present most items carried by air are "time sensitive" — they are needed in a hurry so it makes sense to fly them to their destination even though the actual transport charge is higher than that for other methods. Today's air freight includes computers, fashionable clothes, fresh foods and flowers, newspapers and magazines and every kind of urgently needed spare part — up to a 40-ton propeller shaft without which a big ship cannot earn hundreds of pounds a day.

SKY FREIGHTERS

But most of the world cargo tonnage is "non-time-sensitive" — crude oil, iron ore, gravel, timber, coal — and it is here that aircraft cannot compete with ships, trains and trucks.

If there were a specially built plane to take such bulk cargo perhaps the air freight costs could be lowered and the air cargo market would grow even faster than at present.

For many years, the Boeing Company (builders of the 747) have been looking at this problem and recently they were approached by a group of US industrialists — Husky International — who reckon that the technology exists today to build new freighters of the sky that could slash charges and bring about a colossal expansion in air cargo around the world.

And they needn't be the flying monsters that conservationists are afraid will be the next step in aircraft design. In fact one design that has been studied so far — shown here — would be smaller in span and length than a Jumbo 747, though the laden weight would be about the same. But it would have a very wide fuselage shaped like part of a huge wing, to give lift.

This fuselage would be large enough to carry five cargo bays, each 90 feet (27 m.) long and tailored to the standard 8 ft. (2 m.) high and 8 ft. wide containers carried by trucks, ships and trains.

Above this vast 32,760 cubic foot cargo space would be the flight deck, which would have to be pressurised, of course, although the main cargo holds might not have to be. At the rear would be a giant tailplane carried by twin vertical fins.

The weird flying freighter would be able to use any major airport and fit any of today's large air cargo terminals. Because all five cargo bays could be loaded and unloaded at the same time, the big freighter would need only 30 minutes' turn-round time at an airport.

TWO VERSIONS

Its carrying capacity would be one third greater than that of the Boeing 747F freighter and also that of the truly massive Lockheed C-5A Galaxy military transport plane.

There could be two different versions of the proposed freighter. One would have three engines and would be used for short cargo delivery hops. The other would have four engines and would be able to carry a full 120-ton load a distance of 4,000 miles at a steady cruise speed of 490 mph.

The long-range version could also be re-fuelled in flight and thus could perform vital airlifting duties if America was involved in conflict in far-flung battlefields.

At the moment, the American developers are thinking in terms of 300 new freighters being built, but International Husky think that eventually 1,000 of them could be built and sold. Boeing have said it would take four years to finalise design and construction of the first freighter. But, before work could even begin, no less than 7,500,000,000 dollars (over 3½ billion pounds!) would have to be found for the development costs of the 300 aircraft.

Any offers?

LIFELINER

A Hospital on wheels

RACING to the scene of a big disaster comes a new vehicle from British Leyland which could save many lives in the future. Called the Lifeliner, it is more or less a hospital on wheels equipped with the materials and fittings to deal with badly injured people.

As you can see from the drawing on the left, the Lifeliner contains mobile beds for six patients, oxygen supplies, a mobile generator, plus a complicated patient-monitoring console. It has a special air-suspension system enabling the vehicle to stand level even on rough ground while doctors are attending patients.

People on stretchers are automatically raised to the rear entrance level where the trolleys roll forward ready for medical attention.

Also on the roof is a closed-circuit TV camera which can survey the disaster area.

On the right you can see the dramatic vehicle in action and (below) inside the Lifeliner, where a nurse attends an injured man.

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THE PALEFACED REDSKIN

SEE INSIDE

Speed & Power

GUERILLA FLEET OF THE FUTURE

Vehicles that rise upon underwater wings and shoot across the surface at great speeds are planned as an addition to the striking power of the American navy

A GUERILLA fleet of the future of hydrofoils and large air-cushion ships is planned by the U.S. Navy. Trials have already begun on one of the first of the vessels intended to equip this fleet — a hit and run hydrofoil.

This is Boeing's 235-ton Pegasus which is designed to be armed with rapid-fire cannon and be able to strike and patrol at speeds of 50 knots (57 mph or 91.7 km/hr) and more.

Limited to a 500 mile (800 km) range without refuelling, the Pegasus should be effective along coasts and in narrow seas such as the Baltic, the Red Sea and the Persian Gulf.

Its primary weapons will be ship-to-ship missiles, of which eight will be carried. Complex electronics will control the automatic, rapid-fire 3 in (76 mm) cannon being made in Italy.

With a crew of 21, the Pegasus and its sisters will slice through the water high on their hydrofoils. The propulsion system takes in sea water through struts that connect the vessel's hull to its underwater foils and jets it against the ocean's surface at a rate of 100,000 gallons (454,600 litres) a minute.

To reduce drag, the foils have been designed with an aerodynamic shape that will make high speeds possible. It will be steered by its forward foil, and the ailerons on the rear foil will enable it to make banking turns at high speed, like an aeroplane does.

The success of the tests will determine whether the Americans and other NATO countries will add the Pegasus to their fleets. Attempts will first be made to interest the Germans, and the Americans must also convince their own chief of naval operations, Admiral James L. Holloway, who is gaining a reputation for conservatism in building up the fleet.

They will be able to discover that the transition from hullborne operation to foilborne is both simple and smooth. The exact moment of liftoff is not perceptible.

The automatic control system is set for the foilborne operation and the foil depth selector to the three metre (10 ft) position.

A "ready for flight" announcement is made over the intercom and the throttle is advanced from the idle position.

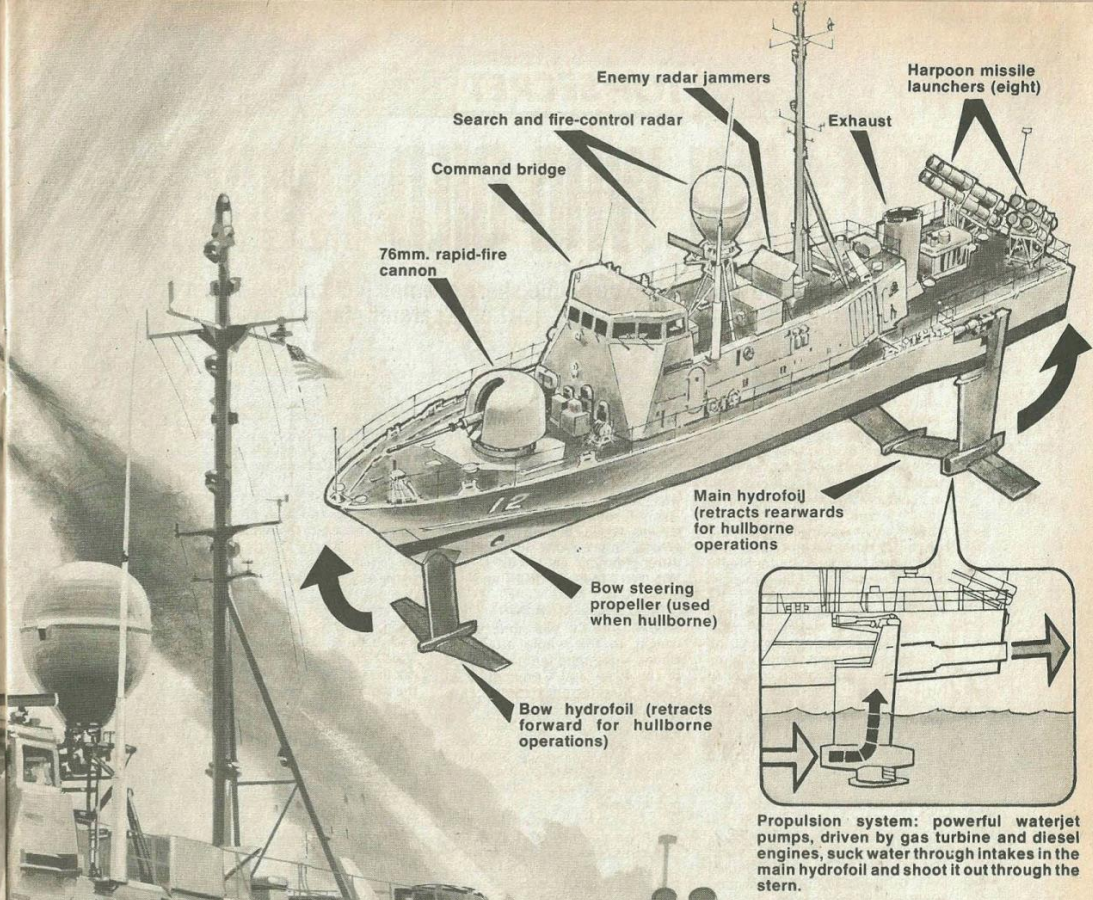
The ship inches up slightly as it accelerates and a slight amount of vibration is felt during the transition.

The change from foilborne to hullborne operation is also barely noticeable. Only when the captain demonstrates the emergency quick landing technique is there a noticeable pitch down manoeuvre and a bump as the vehicle surfaces.

Manoeuvres are performed as co-ordinated banking turns and are smooth. Roll control is exerted principally through the ailerons on the three foils, the forward strut rotating only enough to balance side pressures generated during the turns.

Details of the vessel's performance are secret, but an expert estimated the 50 knots continuous speed quoted at the start of the article.

Subsequent refinements may even lead to greater speeds and increase the vessel's value as a defensive deterrent.



Propulsion system: powerful waterjet pumps, driven by gas turbine and diesel engines, suck water through intakes in the main hydrofoil and shoot it out through the stern.

CITIES IN SPACE

Scientists in America are working out plans for a science fiction type of scheme to house complete human communities in orbiting space worlds, possibly in the next twenty years.

WHAT use do you make of territory after you have conquered it? In the past, the answer has been to live in it. White men went in search of new lands and found Africa, America and Australia and turned these into thriving extensions of their own country.

Man has also conquered space, but the problem of what to do with that is difficult to solve. However, American scientists think that they have found the answer.

Think of a cylinder four miles (6.44 km) in diameter and 16 miles (26 km) long orbiting in outer space. Inside it would be a man-made mini-world with full-scale reproductions of Earthlike communities complete with houses, schools, shops, hills and valleys, trees and streams, roads and wildlife.

This is how some scientists in America propose to make use of the vast emptiness that surrounds the Earth. The cylinder would rotate to produce artificial gravity, but the people living in this space colony would not notice the motion, for everything would be just as it is on Earth with a few pleasant exceptions. There would be no bustling crowds, traffic jams, blaring car horns or fog.

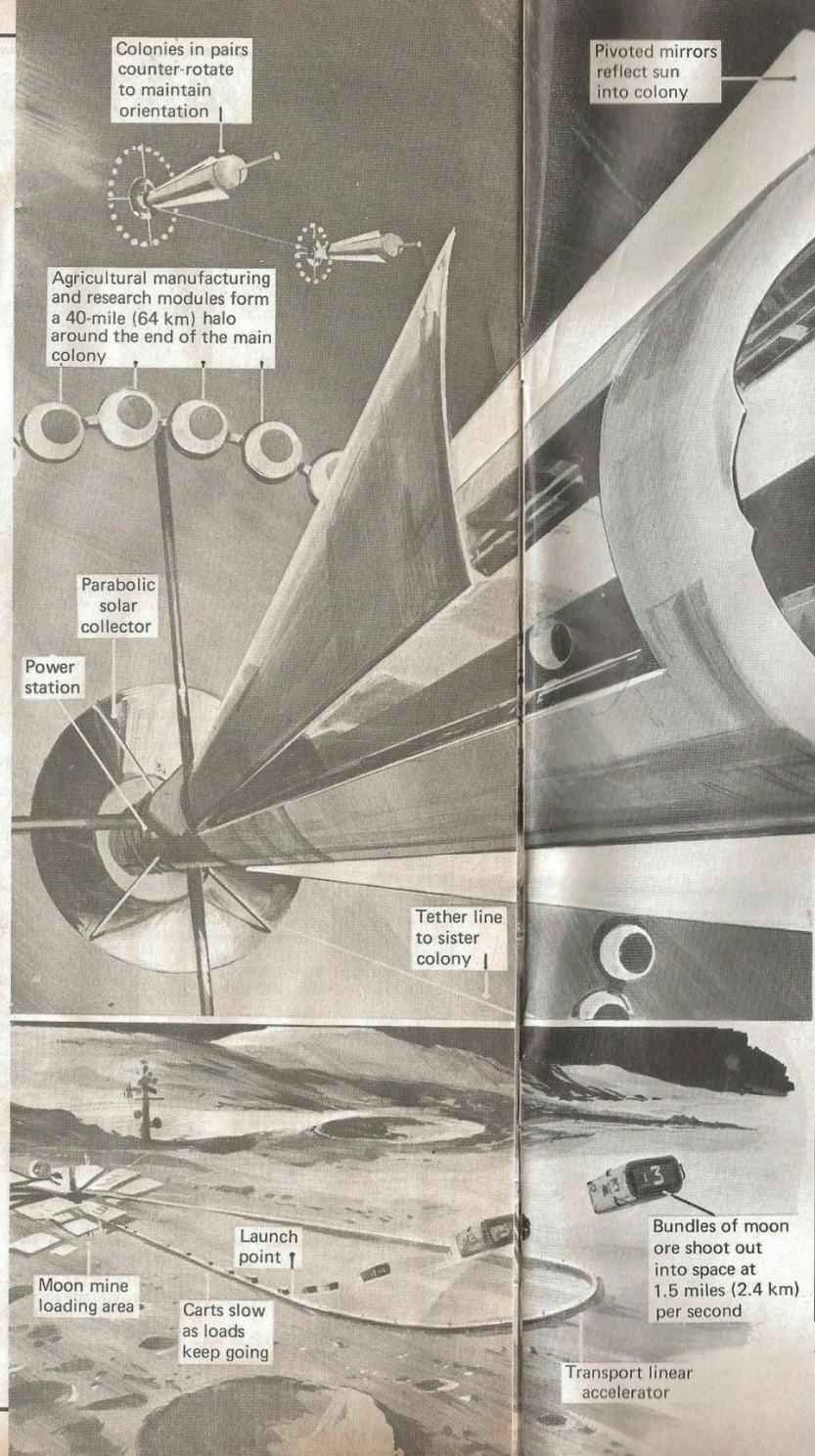
A DREAM THAT COULD COME TRUE

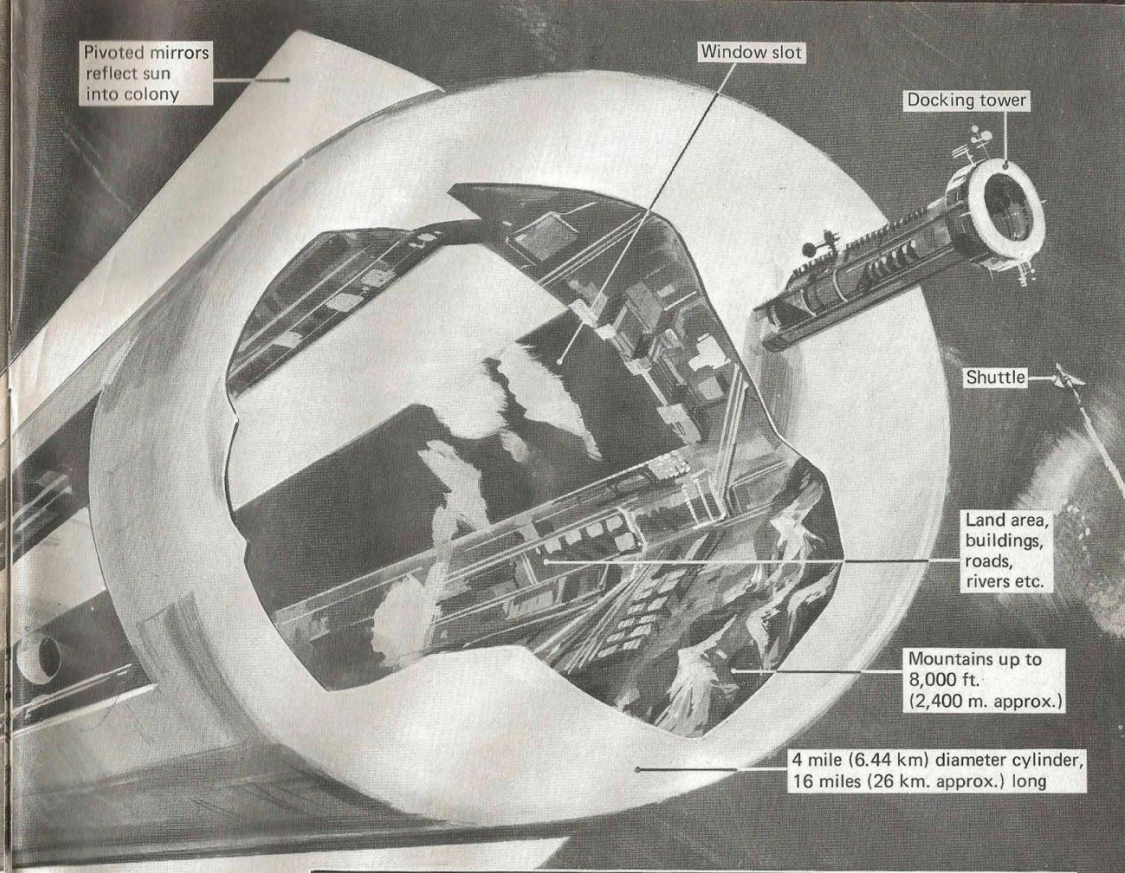
The space colony idea began as an exercise for a group of physics students. At first it was regarded as a joke. But then they saw that these mini-worlds could really be constructed using only the materials and technical knowledge that already exist.

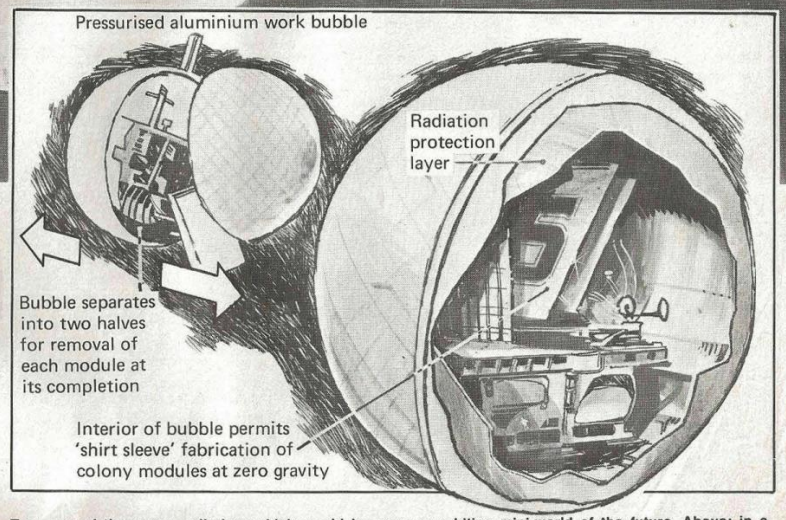
In charge of the project is Dr. Gerald K. O'Neill, professor of physics at Princeton University. He suggests that the first colony would be a small one of 10,000 people. From this would eventually come full-size space communities, with populations of 400,000, encircling the Earth.

Should a decision be reached to begin construction soon, O'Neill believes that the first of these space worlds could be in orbit in the late 1980s. But people will not be able to move in right away. It will take several years, with the use of electrical power from solar energy to get the great cylinders spinning at the correct speed and even longer, perhaps until the end of the century, to make them habitable.

However, in time, they would become self-supporting satellites, drawing upon the moon for their building material and launching this on its path by solar electric power, as shown in our picture on the far right. Science fiction writers have dreamed of such things, but this is a dream that *could* come true.







Top: one of the space cylinders which would become an orbiting mini-world of the future. Above: in a pressurised "bubble" like this many things for the colony could be made. Crops could be grown in a halo of smaller cylinders (left of the top picture). Left shows the method of obtaining materials from the Moon. Containers could be launched into space from a track.

40 PAGES of Action-Packed Fact and Fiction

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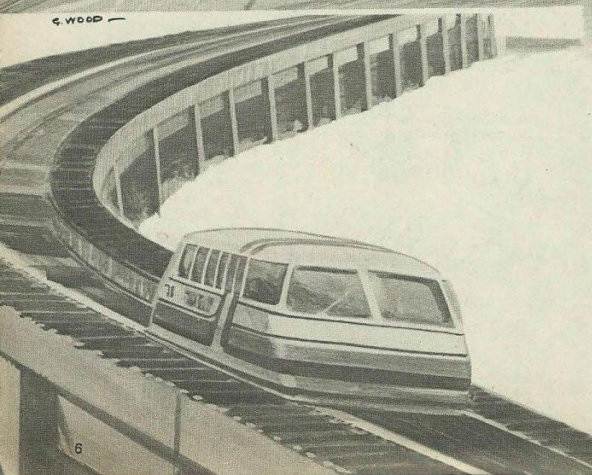
THE FATAL CHALLENGE

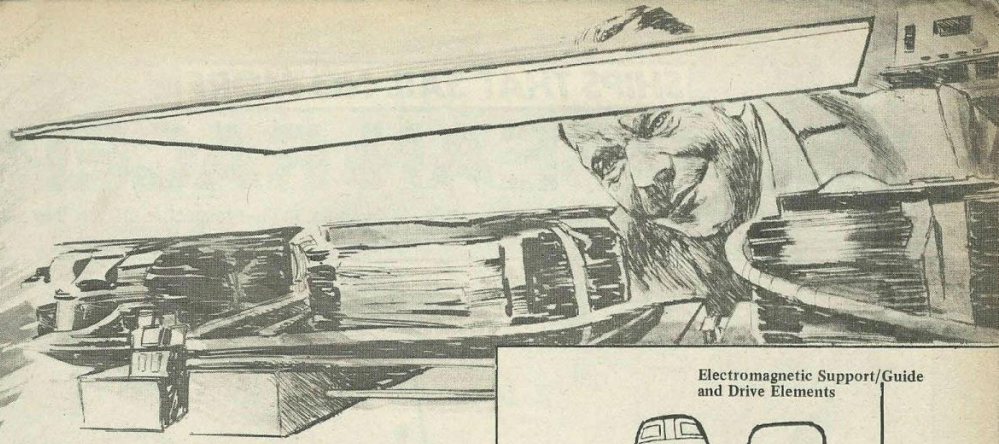
(SEE INSIDE)

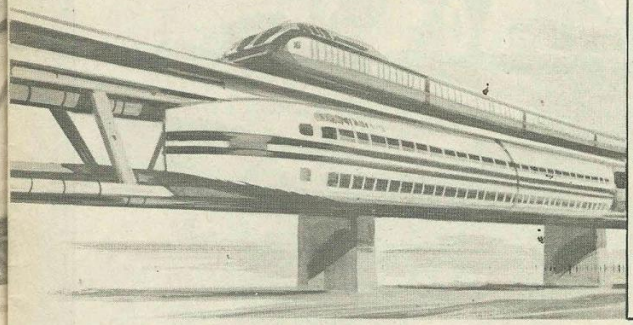
Speed & Power

MAGNETIC MARVELS

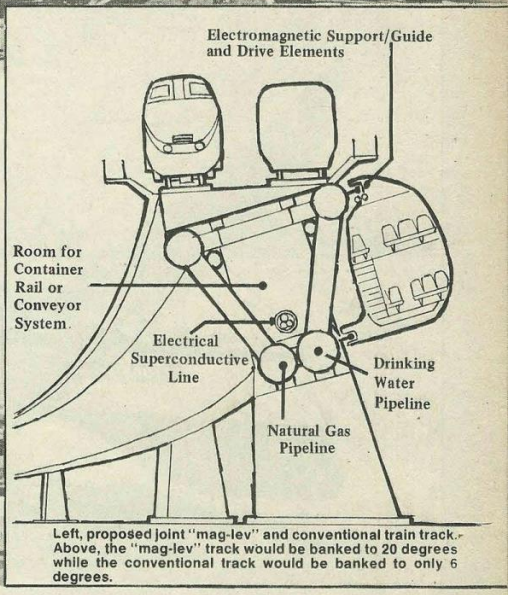


The Japanese have perfected their "bullet" trains which can cover tremendous distances at tremendous speeds. Now it is the turn of the Americans, Germans and the English to pioneer a new dimension in train travel . . .





Left, a German prototype train built to run at 250 miles/401 km. per hour, using magnetic levitation in order to lift the train above the guideway. Below, (left) a German magnetic attraction vehicle called Transrapid. Top, (right), Professor Eric Laithwaite inspects a levitating aluminium plate, an essential part of his transverse flux linear motor.



Left, proposed joint "mag-lev" and conventional train track. Above, the "mag-lev" track would be banked to 20 degrees while the conventional track would be banked to only 6 degrees.

"I believe I have the answer." Professor Eric Laithwaite told himself with some satisfaction. After all, it is not given to all of us to invent and perfect a new method of propulsion.

Laithwaite, Professor of Heavy Electrical Engineering at Imperial College, London, had been asked to design an all-electric linear motor and levitation system to be displayed at the Transpo 72 Exhibition in Washington, U.S.A.

Professor Laithwaite came up with his transverse flux linear motor. The beauty of his invention is that in addition to forward motion, it also imparts magnetic lift.

Laithwaite discovered that a pair of coils gives stable levitation. This is because each coil develops a pushing levitating force, but in the area between the coils, the force pulls. His achievement was to harness this force for movement. So a travelling magnetic field was created with propulsion and levitation combined.

There are still many snags in the system to be ironed out, but recent results have proved promising and the "magnetic river" as it is called, could be the propulsion unit of the future.

American brains and know-how are also being devoted to the problem of speedy yet cheap rail transport. The Americans have two problems. 1. only a small proportion of the rail services are electrified and 2. the wide open spaces of the U.S.A. add a staggering cost/load to any large scale electrification programme.

However, some progress has been made. One idea put forward is for a "caterpillar" train. This would consist of a single flexible unit with a wheel every four feet (1.2 metres) on each side. But it is still very much in the experimental stage.

Another, perhaps, more practical idea is to lay existing tracks with continuous welded rail. Because of their joints, normal rails take quite a hammering over the years, and welded rail lasts longer.

But finance is hampering and crippling these various schemes. The American Government is lukewarm about handing out money and even if it did, most experts agree that the technology would have to come from overseas.

FLOATING VEHICLES

And what better place than West Germany? Here two private consortiums are developing two separate magnetic levitation vehicles. These schemes are receiving massive government financing.

The hope behind these two operations is to overcome the ever-present problem of friction. By "floating" vehicles above the guideway, the Germans are endeavouring to overcome the speed limitations imposed by friction. There is a long-range plan to bisect the country with this super-speed system, and feed it from the sides with high-speed conventional rail.

An even more ambitious plan allows for conduits placed in the overhead track. These could pipe crude oil, natural gas, drinking water, etc. between towns many miles apart.

As we point out in our illustration (above), this 300 mile/481 km. per hour "mag-lev" train would need a bank angle of some 20 degrees for passenger comfort. But a conventional train travelling at the comparatively sedate speed of 180/289 km. per hour vehicle needs only a 6 degree tilt.

In a modern jet plane, it hardly seems possible that one is travelling beyond the speed of sound and now train travellers, it seems, will soon be able to experience the same sensation!

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No. 735, 14th FEBRUARY, 1976
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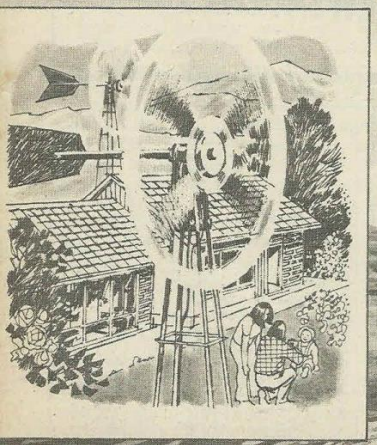
THE REIGN OF TERROR

SEE INSIDE

Putting the Wind to Work

Above: now being tested in America is this strange "egg-beater" wind turbine. Based on 50-years-old European ideas, its blades are aerodynamically-shaped and set to spin in winds of any speed or direction. Later versions would be giant-sized.
Below: many American families in areas remote from electricity supplies already use wind power and storage batteries to run their homes, with an engine-driven generator for emergencies.



'In a world hungry for fuel, why waste the wind when it blows?' ask the experts, who are devising ways of using a source of power that is free

ALL the electricity you need and no bills to pay. That's a fantastic dream if you like. But it is not so incredible as it sounds. In fact, it is perfectly possible with a windmill.

Don't think of the creaking wooden windmills you have seen in old pictures of Holland, but modern metal ones that are highly efficient and run electrical generators. They provide enough current to power a house or a farm and charge up batteries, so that the user can still have electricity, even when the wind has dropped.

With the ever growing cost of fuel, the idea of installing a windmill is proving popular, especially in places like the United States where farms and homesteads are so isolated that power lines are expensive to install.

That wind power is perfectly feasible is demonstrated by the enterprise of Mr. John Lorenzen, a corn farmer of Iowa. In the 1930s, the American power companies were linking up rural places to the mains supply. But Mr. Lorenzen declined to be linked up.

Today he is glad, because he has windmills which provide enough power to run a host of electrical equipment from domestic appliances like TV and vacuum cleaners to all the machinery in his workshop varying from a power lathe to a motorised hacksaw.

Farmers who wish to follow his example are encountering a big drawback in the high cost of wind generators. But America's National Aeronautics and Space Administration has decided to study the energy problem as well as its space projects.

They have produced a prototype windmill for the future. This is a 100 kW experimental wind turbine generator which could supply thirty homes with power.

Other people have produced a wild variety of windmill designs. German engineers on the island of Sylt have made a machine with a horizontal axis whose two sets of blades turn in opposite directions.

In America, an engineer has designed a house incorporating two wind generators to provide electricity. Mass production, he considers, would reduce the price of the equipment to the same as that of a large colour TV.

Another idea is for a windmill that looks like the toy kind you buy at a fair, and yet another has the appearance of an aircraft without wings on a pole.

CONTINUED ON NEXT PAGE ▶

Ocean racing yachts skim past a group of wind generator towers. Such towers, floating out at sea or built on remote sea shores in areas of high average wind speeds, would be designed to extract the utmost energy from the wind and convert it into electricity to be fed into the power grid or to produce hydrogen gas. This would be burnt in power stations or vehicles.

The biggest-ever wind generator so far was built at Grandpa's Knob, Vermont, U.S.A. Its size is shown by the men (inset) drawn to the same scale (right). During experiments, it was used several times to supply power to the local area until, in 1945, one of its mighty eight-ton blades ripped apart, causing the project's cancellation.

But whatever they look like, they are all designed to turn the wind into electrical power.

Nobody can say what design holds the best chance of success. Researchers at Oklahoma State University are backing their Super Speed Turbine which is like an outsize bicycle wheel with aluminium blades fixed to the spokes.

How to save electricity for use during a calm is still a problem. It could be put into batteries, turn giant flywheels, compress air or make hydrogen for use as fuel.

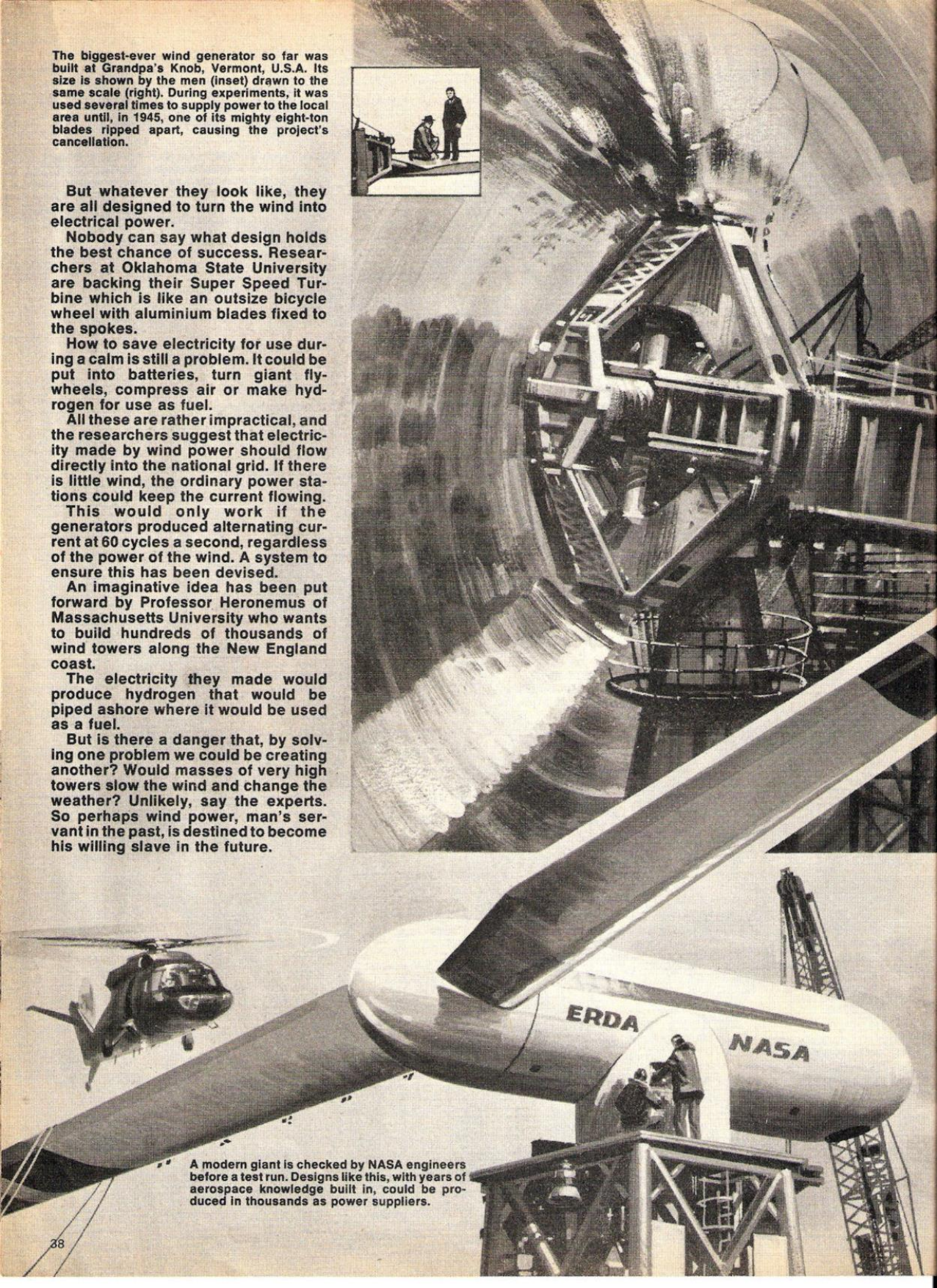
All these are rather impractical, and the researchers suggest that electricity made by wind power should flow directly into the national grid. If there is little wind, the ordinary power stations could keep the current flowing.

This would only work if the generators produced alternating current at 60 cycles a second, regardless of the power of the wind. A system to ensure this has been devised.

An imaginative idea has been put forward by Professor Heronemus of Massachusetts University who wants to build hundreds of thousands of wind towers along the New England coast.

The electricity they made would produce hydrogen that would be piped ashore where it would be used as a fuel.

But is there a danger that, by solving one problem we could be creating another? Would masses of very high towers slow the wind and change the weather? Unlikely, say the experts. So perhaps wind power, man's servant in the past, is destined to become his willing slave in the future.



A modern giant is checked by NASA engineers before a test run. Designs like this, with years of aerospace knowledge built in, could be produced in thousands as power suppliers.

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SEE INSIDE HOW AN ICE-BREAKER OF THE FUTURE WILL PIERCE THE ARCTIC'S THICKEST ICE

Speed & Power

Now in the design stage is an oil tanker which, given a thrusting force of thousands of tons, will cleave its way through the thickest ice with . . .

THE WORLD'S TOUGHEST NOSE

BREAKING through the thick Arctic ice should be as easy as slicing through a crisp wedding cake to an oil tanker of the future, if it fulfils the hopes of its Norwegian designers.

With their eyes on the business that would come the way of a ship able to bring oil from the ice-coated Alaskan ports to warmer harbours further south, they have thought up a ship with a dual-purpose, ice-destroying bow.

This would operate at two levels. When the ship is crunching its way through the frozen sea, it will pierce the ice in the same way as an ordinary ice-breaker. Its dead weight would then be 250,000 tons.

But if the ice becomes too tough for this treatment, the captain would pump in 60,000 tons of ballast water. As the ship sank further into the water under this increased weight, its peculiarly-shaped bow would descend beneath the ice.

It would then be able to jettison its ballast water and rise to burst apart the ice from beneath, shearing away the dense wall of frozen water that is an insuperable barrier to many other ships.

Known as an SSIT or Semi Submarine Icebreaking Tanker, the vessel would be 360 metres (nearly 400 yards) long and could carry twice as much oil from Alaska to America as two equivalent tankers operating between the U.S.A. and the Gulf.

Most of its efficiency would rest upon its ability to forge through ice that held back other ships. Usually, ice-breakers are built with enough power to cut through the ice at a steady rate. But if the ice becomes too thick, they have to ram it. To do this, they reverse and then charge forward at the ice. The new tanker could do this, but it should not need to do so very often because of its specially designed hull and great power.

But if it did encounter trouble, it would have a unique solution. While the vessel's nose was still under the ice, the captain would discharge about 30,000 tons of water ballast from the forward tanks. This would give the vessel a vertical uplifting force in the region of 40,000 tons. As the immense bows rose, they would fracture the ice like a miniature earthquake and allow the ship to burst up from underneath.

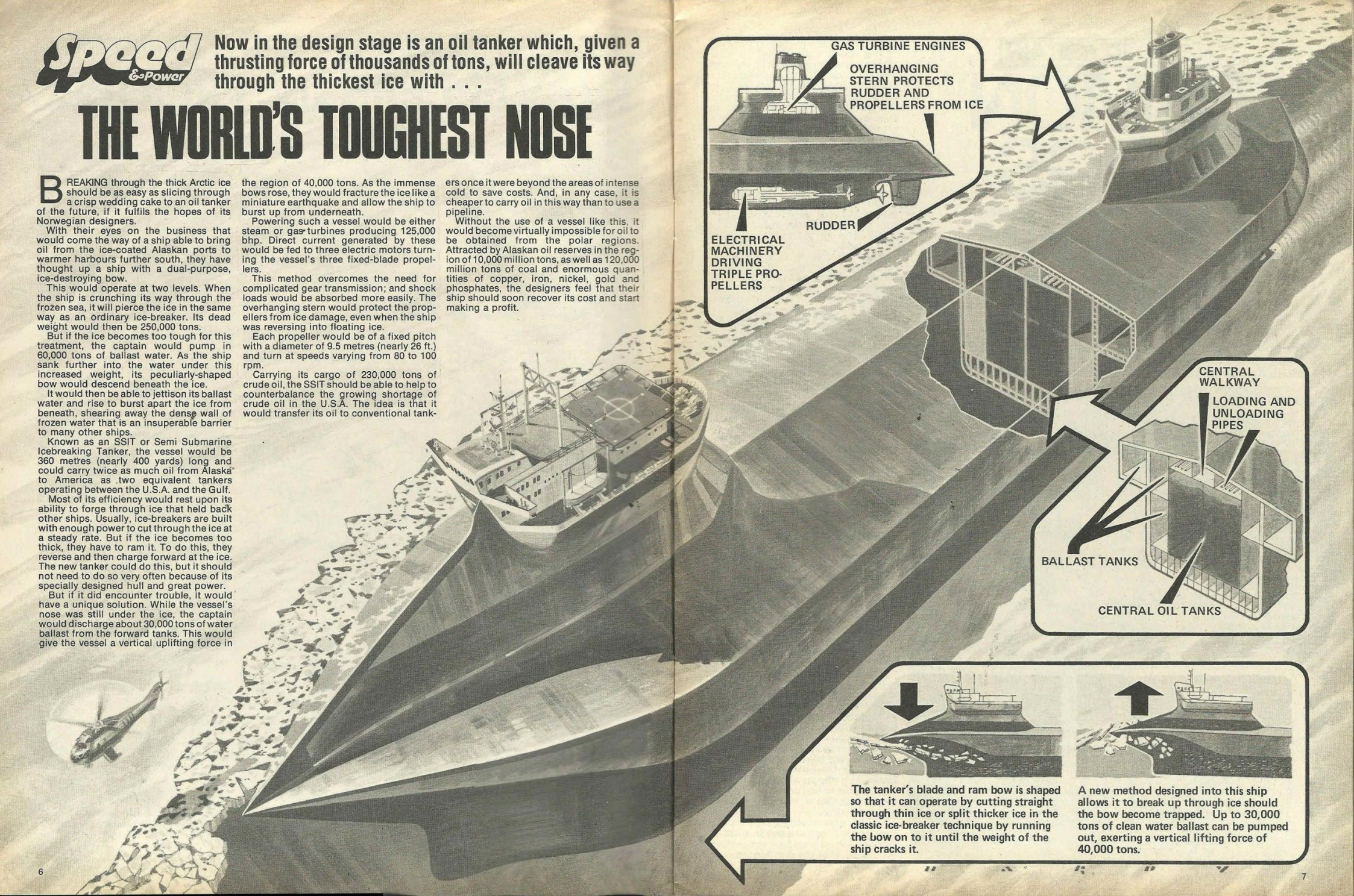
Powering such a vessel would be either steam or gas-turbines producing 125,000 bhp. Direct current generated by these would be fed to three electric motors turning the vessel's three fixed-blade propellers.

This method overcomes the need for complicated gear transmission; and shock loads would be absorbed more easily. The overhanging stern would protect the propellers from ice damage, even when the ship was reversing into floating ice.

Each propeller would be of a fixed pitch with a diameter of 9.5 metres (nearly 26 ft.) and turn at speeds varying from 80 to 100 rpm.

Carrying its cargo of 230,000 tons of crude oil, the SSIT should be able to help to counterbalance the growing shortage of crude oil in the U.S.A. The idea is that it would transfer its oil to conventional tankers once it were beyond the areas of intense cold to save costs. And, in any case, it is cheaper to carry oil in this way than to use a pipeline.

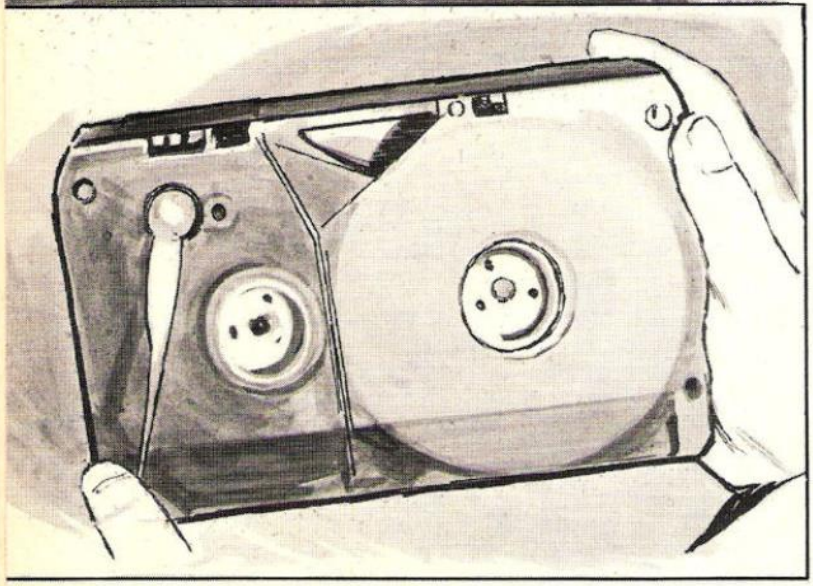
Without the use of a vessel like this, it would become virtually impossible for oil to be obtained from the polar regions. Attracted by Alaskan oil reserves in the region of 10,000 million tons, as well as 120,000 million tons of coal and enormous quantities of copper, iron, nickel, gold and phosphates, the designers feel that their ship should soon recover its cost and start making a profit.



The tanker's blade and ram bow is shaped so that it can operate by cutting straight through thin ice or split thicker ice in the classic ice-breaker technique by running the bow on to it until the weight of the ship cracks it.

A new method designed into this ship allows it to break up through ice should the bow become trapped. Up to 30,000 tons of clean water ballast can be pumped out, exerting a vertical lifting force of 40,000 tons.

Big screen TV is possible from a small, compact projector of the kind shown below. Made by a Japanese firm, it can project either video tape or TV pictures on to a large screen that is curved, silvered and highly reflective. Perfectionists can have stereo sound from loudspeakers mounted beside the screen or in its base. So far, only the wealthy can afford it at around £1,500.



Cassettes of this size (the hand gives you something for comparison) carry colour programmes that the projector converts into pictures of home movie dimensions.

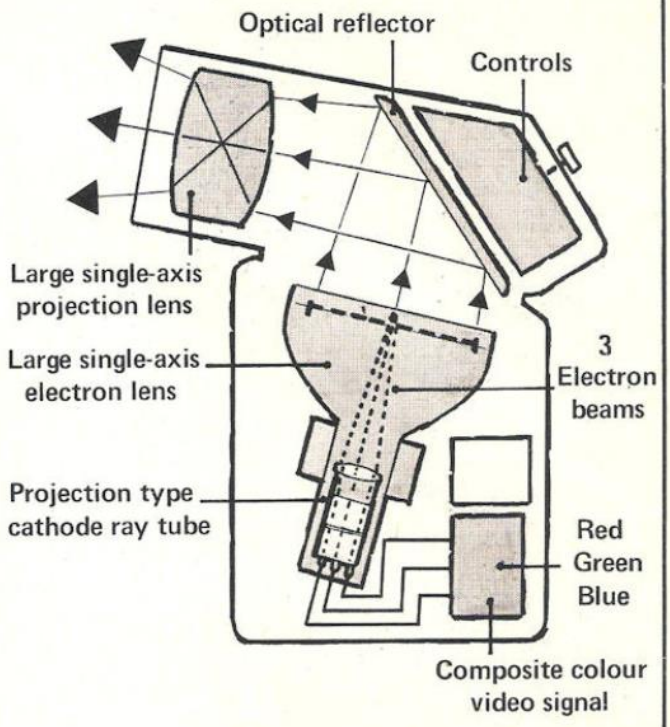
Speed & Power

In this special four page feature we look at the . . .

MAGIC IN A MATCHBOX

A close-up of the TV projector shown in use on the left. The slider controls include picture contrast, brightness, hue and tint. Dual controls adjust volume from left and right. On the top is a VHF/UHF tuner.

Video Beam Projection Colour Television



To make a television camera no bigger than a matchbox sounds an astonishing feat, but it is a possibility, thanks to tiny chips of silicon that do the work of a whole boxful of electrical bits and pieces

REALLY big screen TV with the picture projected on to a free-standing screen with the added realism of stereo sound could give a new look to home entertainment in the future.

Not only will you be able to see and hear Kojak in his New York police precinct or watch a concert at the Albert Hall, depending upon your preference, but you will feel that you are really at the heart of things.

Television equipment that will make this possible is being developed and it should be only a matter of time before such things are within the reach of all with a few hundred pounds to spare.

The vital device that will make it all possible is known in electronic circles as an IC or integrated circuit. It's a tiny silicon chip with so many components and circuits embodied in it that it can do the job of a box full of transistors, diodes, capacitors, resistances and other bits and pieces that go into a piece of modern equipment.

Experts have now taken the IC one stage further by producing a CCD which is a charge-coupled device. This is a versatile device which could be used as a computer memory, the "eye" of a TV camera or a signal processing component in a radar set.

Equipment incorporating the CCD is already being tested. One of the things it should make possible is a TV camera so small you could carry it in your coat pocket.

A single CCD only millimetres thick will serve as the camera's tube (by which vision is turned into an electrical signal) and all its circuitry. Just a lens and a sight for the cameraman will make the camera complete.

CCDs have the advantages of being reliable, strong and of using less dangerous voltages. But, they have a long way to go before the picture they record is as good as that of their bigger brothers. In America, one such camera, about the size of a two inch or 51mm. cube, produced pictures that were crude by comparison with ordinary TV cameras. But no doubt, in time, the shortcomings will be overcome.

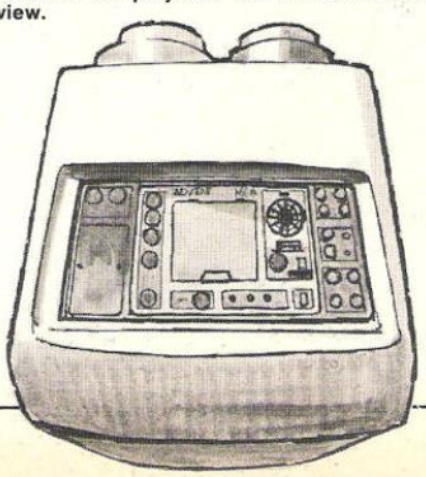
It should be put a small step from this to the CCDs used in equipment of the kind you can see on these pages.

One of the most striking should be the projector TV. A Japanese version can be

CONTINUED ON NEXT PAGE ▶

This diagram shows a colour TV projector whose picture comes from a tube and is reflected through a mirror and lens on to a screen.

Three colour tubes project the red, blue and green elements that make up a TV picture. Below is the projector with its controls on view.



bought in Britain for providing colour TV pictures as big as those of a home movie projector.

This unit projects a large picture on to a special, curved, silvered and highly reflective plastic screen. The screen's curve matches the curve of the projector's lenses so that the picture is sharply in focus all over.

Users will be able to show ordinary TV programmes or play their video cassettes in true-to-life colours.

This set projects its colours through one tube and lens. Another version uses three colour tubes to project the red, green and blue elements that make up a colour TV picture.

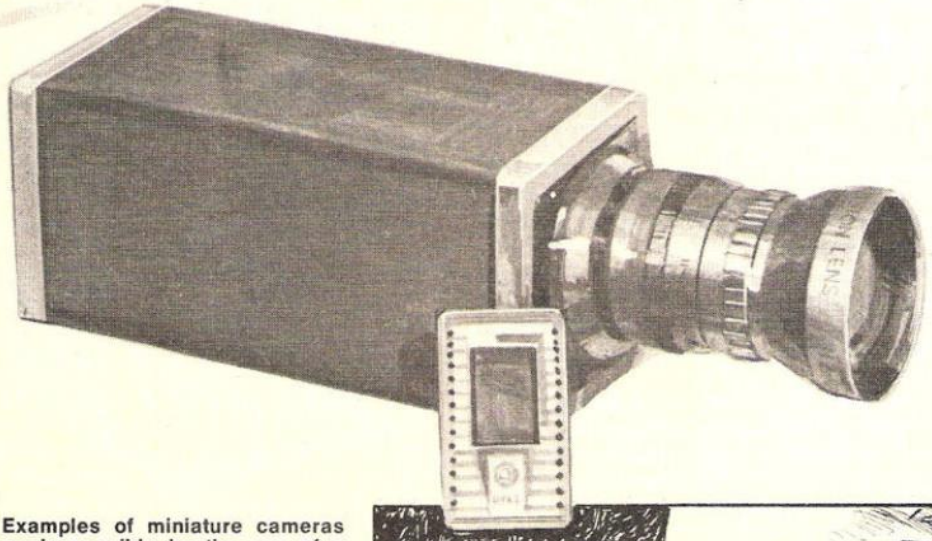
The receiver-projector receives the TV signal in the normal way. All of the electronic steps needed to produce a TV picture take place inside the projector unit, so that all the projector emits is a beam of light.

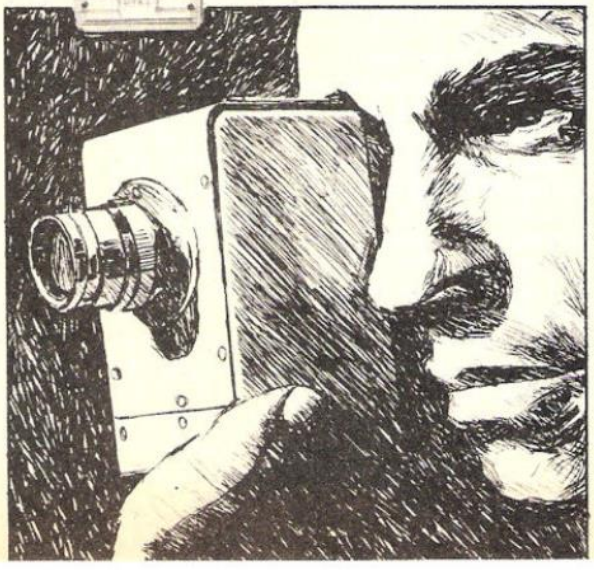
As the electron beam that produces the picture is not projected, there is no radiation hazard.

The screen is an advanced kind of cinema screen with a curved surface made from a highly reflective aluminium material.

To add to the realism for viewers, the sound is beamed at the screen from a single loudspeaker, so that it appears to be coming from the heart of the action.

Another logical development in the use of up-and-coming devices like the CCD is the video telephone which enables you to





Examples of miniature cameras made possible by the use of a charge coupled device (CCD) chip. Top picture shows a prototype being tested in a laboratory. Above is a TV camera containing what is claimed to the world's largest integrated circuit (see article for an explanation of such a circuit). This is a CCD which is said to produce a picture as good as an ordinary television camera.

On the right is a miniature TV camera which, claim its makers, could be made even smaller. Its CCD turns visual images into electrical charges which can be processed to reassemble the TV picture on a screen. The picture is said to be very sharp.

Picturephones like this may be in all our homes some time in the future. They are being made practical propositions by the invention of the CCD which enables the makers to use tiny TV cameras in their Picturephones. Their first use will probably be in industry and commerce because of their high cost. Mass production may later make them available widely so that anyone with a telephone can have a Picturephone in their home.

see as well as hear the person you are speaking to.

American companies have made experiments with these. But in Britain, the Post Office is letting their project for a viewphone tick over, while they keep an eye on what the Americans are doing.

One day, it will sweep into use, when ways have been found of cutting the great costs involved.

The first and most important use would probably be for business men who would be able to have face-to-face consultations with their clients, no matter how far apart they might be physically. Documents could be displayed and examined. On the personal level, families and friends may find a "meeting" by TV phone almost as satisfactory as a visit, with the added advantage of saving in travelling time and costs.

The fuel savers point out that a gallon of petrol will propel a car for about thirty miles. The same energy would provide 66 hours of conversation on a TV phone, for the only "fuel" required is electricity.

However, the initial cost of installing a TV phone system would be very high. Because of this, the Post Office in Britain is in no hurry to race ahead with TV phones. Instead, they are more interested in facsimile transmission. This is a method by which documents can be transmitted by wire and reproduced at the other end by a device like a photo-copying machine.

Perhaps it would interest the technically minded to have a more detailed look at a CCD. The first was simply an array of closely spaced electrodes on a layer of silicon dioxide insulator, covering a silicon chip. If a voltage was applied to the electrode, the region beneath it in the silicon became depleted of carriers, creating a potential well. A packet of charge could be stored in this region at the interface between the silicon and the insulator.

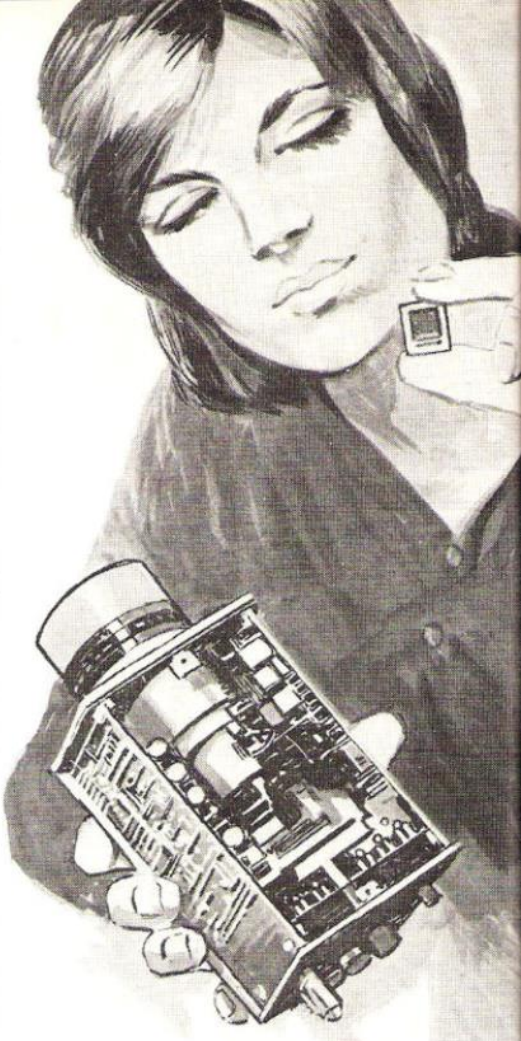
Then, by varying the voltage on the electrode, the depth of the well could be changed. And if the electrodes were spaced close enough, the charge could be transferred from one to another, tipping it from one potential well into a deeper one.

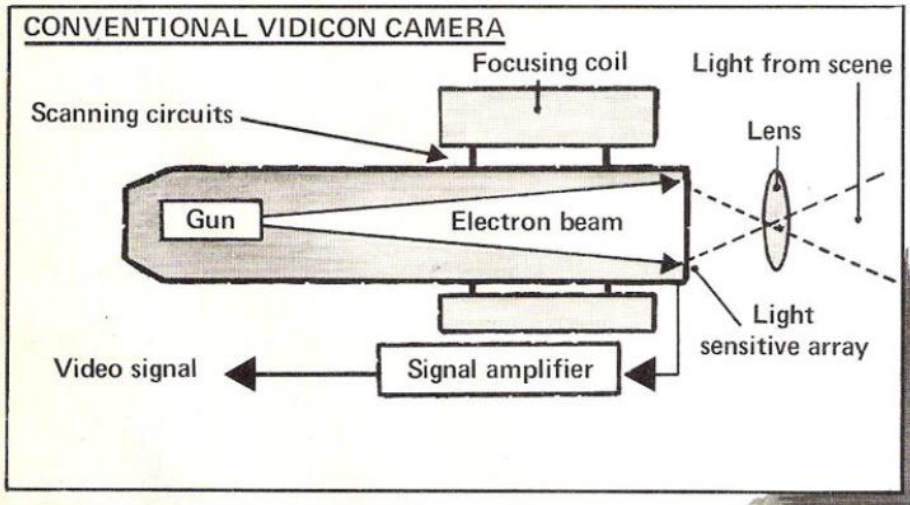
For its use in TV, the light from the scene is focused on the surface of the silicon chip where it produces a pattern of charge with the aid, in some cases, of photo-sensitive devices.

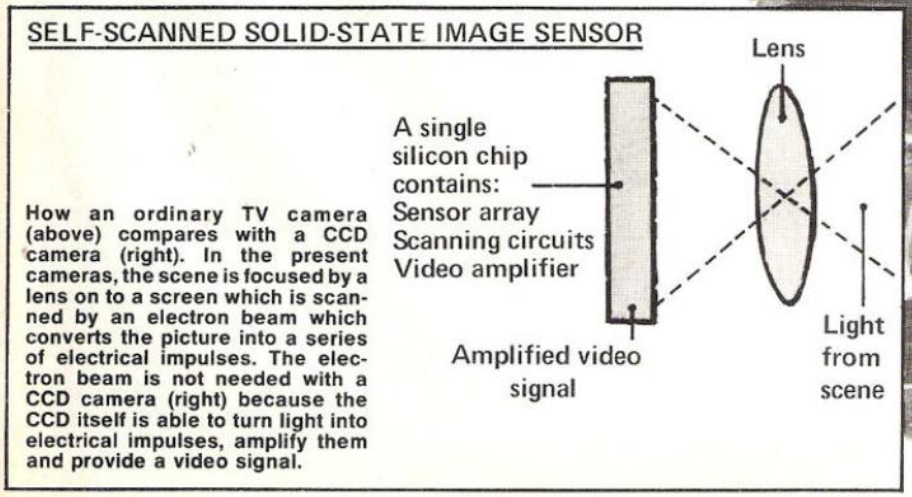
This charge becomes a signal which can be amplified like the output from a conventional TV camera.

One advantage of the CCD is that it can be used where there is little light, such as perhaps with military and security equipment. A high-quality camera of this type is sensitive enough to take good pictures by the light of a candle.

Clearly, we can expect big developments in the field of electronics in the next few years with improvements in television devices racing ahead very quickly. We can only hope that the quality of the programmes keeps pace with the excellence of the equipment.

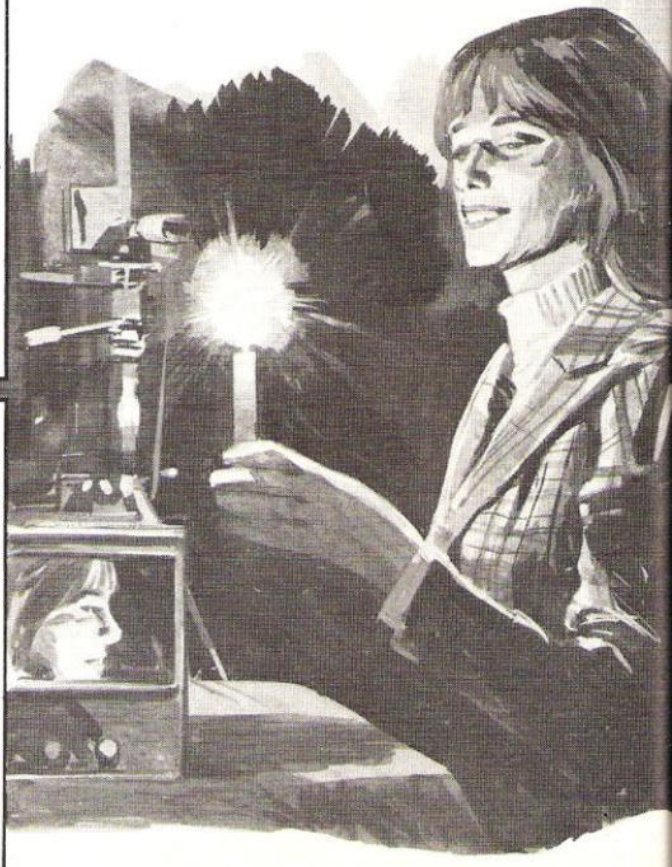






How an ordinary TV camera (above) compares with a CCD camera (right). In the present cameras, the scene is focused by a lens on to a screen which is scanned by an electron beam which converts the picture into a series of electrical impulses. The electron beam is not needed with a CCD camera (right) because the CCD itself is able to turn light into electrical impulses, amplify them and provide a video signal.

Cameras you can hold in one hand are being made with CCD devices as small as that being held between two fingers (top). Some are so sensitive that high-quality pictures can be taken by the light of a candle (below).



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INSIDE- Part 1 OF YOUR POCKET BOOK OF HEROES

Speed & Power

Why Waste The Waves?

Bothered by this question, scientists have been busy working out ways for turning the restless oceans into sources of electricity

SITTING in his office in Virginia Key, Miami, U.S.A., Dr. Harris B. Stewart watched the Gulf Stream churning its way through the warm seas.

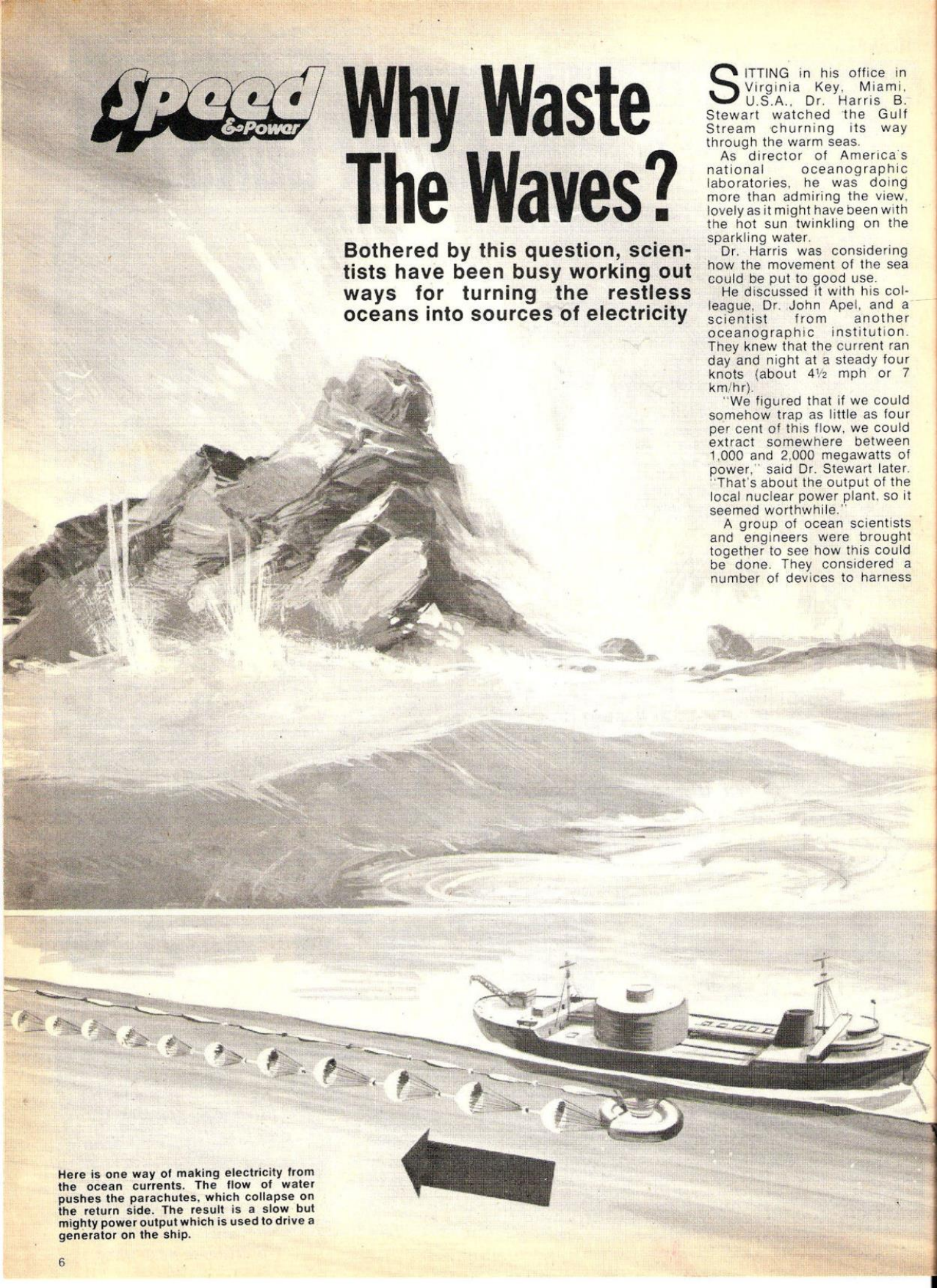
As director of America's national oceanographic laboratories, he was doing more than admiring the view, lovely as it might have been with the hot sun twinkling on the sparkling water.

Dr. Harris was considering how the movement of the sea could be put to good use.

He discussed it with his colleague, Dr. John Apel, and a scientist from another oceanographic institution. They knew that the current ran day and night at a steady four knots (about 4½ mph or 7 km/hr).

"We figured that if we could somehow trap as little as four per cent of this flow, we could extract somewhere between 1,000 and 2,000 megawatts of power," said Dr. Stewart later. "That's about the output of the local nuclear power plant, so it seemed worthwhile."

A group of ocean scientists and engineers were brought together to see how this could be done. They considered a number of devices to harness



Here is one way of making electricity from the ocean currents. The flow of water pushes the parachutes, which collapse on the return side. The result is a slow but mighty power output which is used to drive a generator on the ship.

this slow-moving mass of water.

These included:-

A honeycomb of giant turbines that would drive generators.

Vertical, egg-beater-like propellers geared to generators.

Rotors with cupped blades and huge, underwater "windmills" with two-bladed propellers that also drove generators.

There was even an ingenious idea for a string of parachutes running as if on a conveyor belt, as illustrated on the first page of this feature.

However, there was no quick and easy answer to the problem and the experts embarked on a research and development programme before they decided on which system was best suited to the conditions of the Gulf Stream.

Perhaps mechanical movement was not the way to use water power. Could the variations in temperature between sea water on the surface and that in the depths be used in some way?

Those were the lines on which other scientists were working when they hit upon a startling idea. They knew that, heated by the sun, the surface of an ocean may be 30-35 deg. F. warmer than the waters farther down. "Was there some way in which these temperature variations could be used?" they mused.

Then someone thought of the way a refrigerator works. This uses ammonia to extract heat from inside the cabinet. When it is running through the pipes that are outside the refrigerator at the back, the ammonia expands and becomes a gas.

The same principle was suggested as a way of getting energy from the sea. In this case, as the ammonia is warmed by the sea, it expands and its pressure turns turbine blades which drive a generator to make electricity. At this stage, the ammonia is a vapour which, as it leaves the turbine, passes through a condenser which is chilled by cold, deep water.

This turns it back into a liquid, and it is then pumped around again to keep the turbine blades turning.

You can see a full explanation of this with a diagram at the bottom of this page.

Scientists in the Scripps Institute of Oceanography, California, U.S.A., have drawn up a chart showing how much untapped power is made by the movement of the sea, and they have contrasted this with the world's power needs in the year 2000.

It is quite clear from this that a great deal of energy is going to be needed, and also that there is a tremendous amount available. Extracting it is the problem.

One of the men who is tackling it is Dr. Andrew Salter of the University of Edinburgh's

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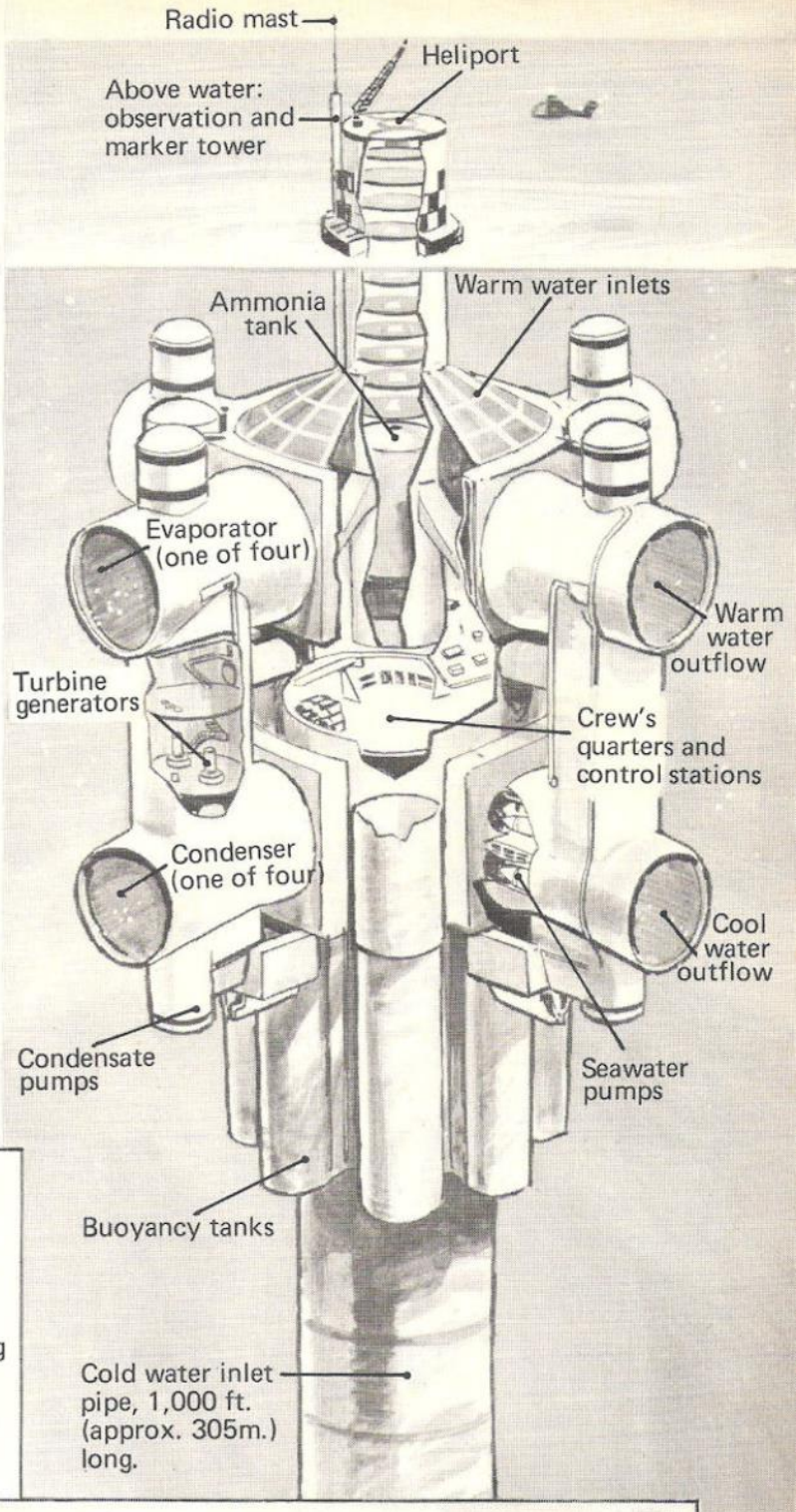
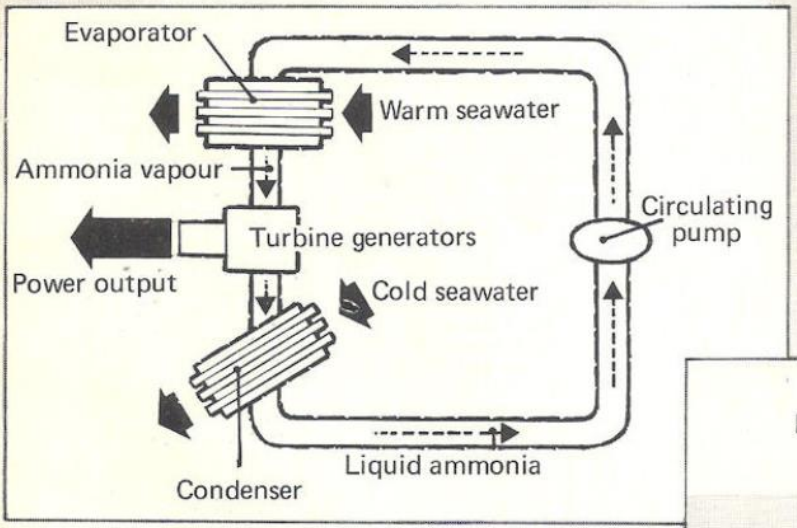
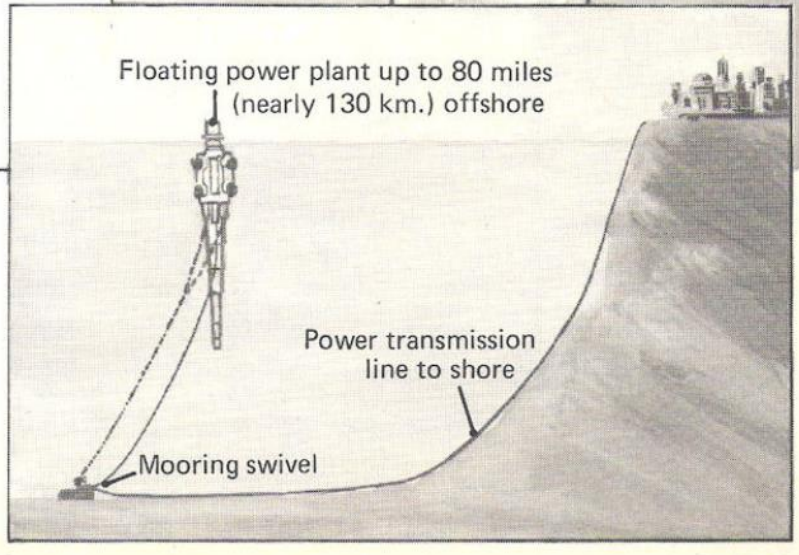
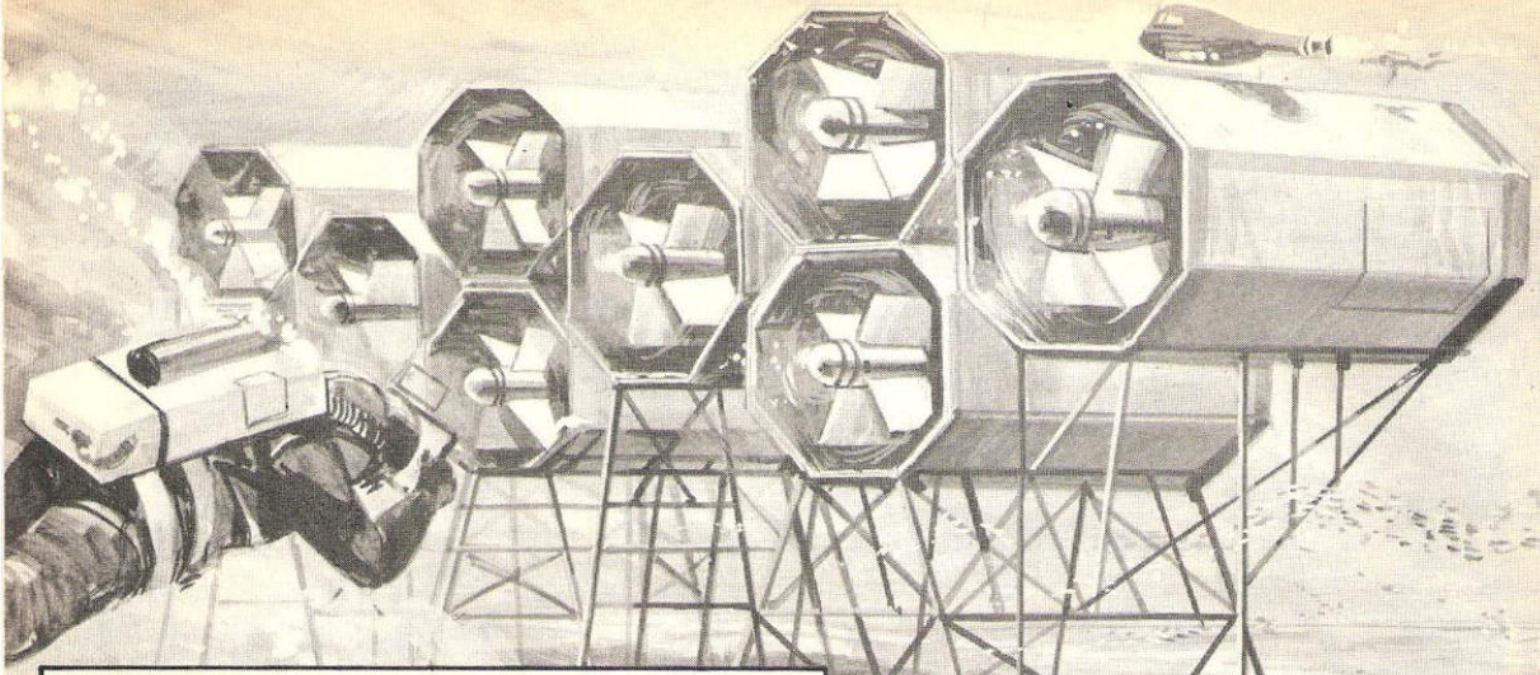
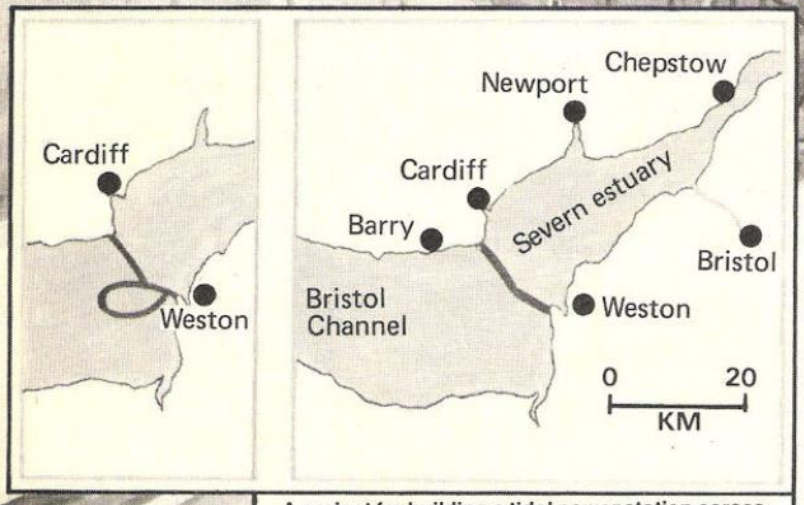






This device uses the sea's temperature variations to make electricity. Basically the idea is that ammonia is cooled by water from far below the surface. This causes the ammonia to become a liquid. It is then passed through an evaporator warmed by water from the ocean's surface, where it is 30 or more degrees F. hotter. As the ammonia is warmed, it vaporises and expands, setting up a pressure which enables it to turn turbine blades. The turbine drives a generator which makes electricity. As the ammonia leaves the turbine, it passes through a condenser cooled by deep water, and the cycle is repeated.





A project for building a tidal power station across the Severn estuary has been put forward (above right). But the tides would not allow electricity to be made when it was most needed. A better idea would be the two-reservoir system (above left), which would provide electricity when required.

Department of Mechanical Engineering.

He has designed a device, about the size of a supertanker, with 20 or 40 large vanes which would be moved up and down in a swivelling motion by the waves.

This motion would pump water, under high pressure, through a turbine generator to make electricity.

Tidal motion is also an attractive source of power, one that has been investigated by Walter Marshall, chief scientist at the Department of Energy. He has agreed to suggestions that the Severn Estuary would be a good site for a tidal barrage

Giant underwater turbines like these are also being studied as a means of generating electricity.

where the flow of water could be made to turn turbines.

This system is being used in Brittany, where a tidal power station — the only one in the world — stretches across the mouth of the River Rance.

When the tide begins to rise, its sluice gates are opened to allow the water to fill a basin above the dam.

The trapped water is allowed to run through turbines three hours after the high tide mark has been passed. As the turbines spin, they generate electricity and continue to do so until just after low tide.

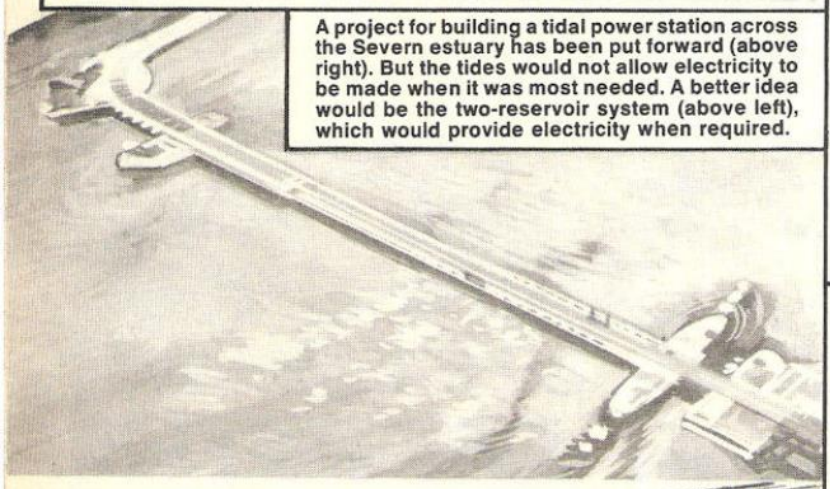
As there are 24 generators, each rated at 10 megawatts, the total output of the Rance plant is 240 megawatts, and it feeds 500 megawatt-hours a year into the French grid (a megawatt is a million watts).

Built in 1966, the Rance plant has proved to be a success.

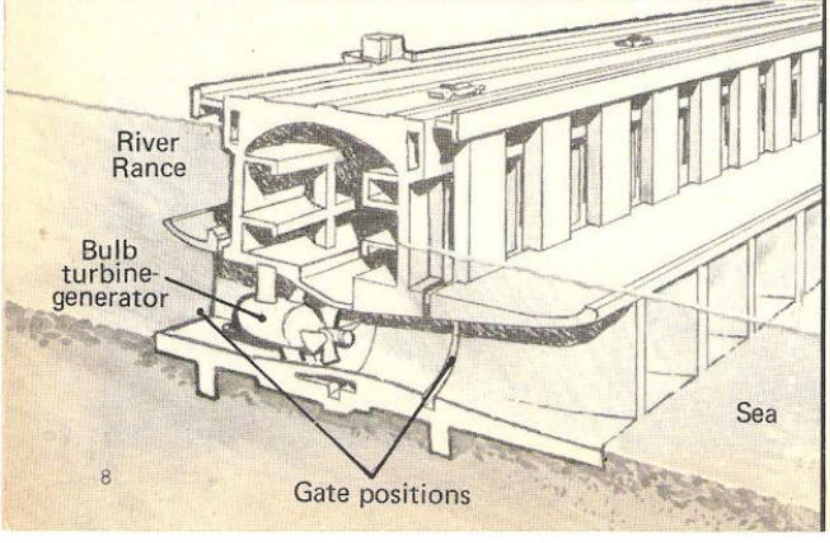
At its heart are the 24 turbine-generators which combine a horizontal-axis propeller turbine with variable pitch blades and a generator housed in a watertight nacelle or bulb.

This complete assembly is underwater and is made to generate current with the water flowing in either direction, using cheap, off-peak electricity to increase the amount of water in the basin behind the dam.

It is setting an example which other nations may begin to follow in their desire to turn the restless energy of the sea to good purpose.



An aerial view of the world's only commercial tidal power station. This is at the mouth of the River Rance in Brittany. It has a total power output of 240 megawatts and contributes 500 megawatt-hours a year to the French grid.



Cross-section of Rance's tidal barrier. The heart of this installation is the 24 turbine-generators housed below the water in pods. The turbines can be spun by water flowing in either direction and can be used as pumps when necessary. As the trapped water runs through them, the turbines spin and turn the generators, each of which is rated at 10 megawatts. Their 18 foot (nearly 5½ metre) blades can have their pitch varied to match the water flow.

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PRINCE ARTHUR SLAYS THE GIANT

SEE INSIDE

Speed & Power

POWER FROM THE SUN

A ray of sunshine is being shed on the world's fuel problems by scientists who are finding ways of tapping the sun's inexhaustible supply of energy

TWO of the world's most abundant raw materials, sunshine and sand, may be combined to provide us with a new source of energy.

Scientists have long tried to find ways of turning the sun's heat to a good industrial use. It has been used to warm water trickling over panels exposed to sunshine, and in the south of France multiple mirrors reflect the sun's rays into a furnace where an intense heat is created.

But it is in the generation of electricity that sunshine is given its most flexible use. And it is in this connection that it becomes a partner of sand. Electricity is made when the sun shines on solar cells made of silicon which is obtained from sand, for sand is mostly silicon dioxide.

Unfortunately, the high cost of silicon solar cells has restricted their use in the generation of electricity. An installation in America of 20 panels of cells with the power of 1,000 watts cost £12,800 or £12.80 a watt. At these prices, solar cells have been used chiefly in space vehicles where their expense cannot be avoided.

However, with the world's oil reserves being used up at an alarming rate, nuclear power stations still limited in output, and coal costly to mine, the need to develop a cheaper solar cell is given increased urgency.

Experts feel sure that the cost of such cells can be cut to about 25p. a watt in a couple of years or so. At such a figure, solar generators for homes, offices, shops, schools and factories are a practical possibility.

To make electricity, solar cells use what is called the photovoltaic effect. They turn light directly into electricity without any physical movement. Sunshine striking a solar cell causes electrons to be produced in the cell.

Another proposal being examined is for solar farms, endless fields planted with heat-trapping devices that "grow" electrical power from sunlight.

The idea has been developed by the American husband-and-wife team of research scientists, Dr. and Mrs. Aden B. Meinel. They have based their system on the heat-trapping qualities of micro-thin layers of gold, hafnium, quartz and other crystals, elements that can be bonded together in sandwich-like panels.

These panels work a little like a greenhouse, letting solar heat in and then stopping it from escaping. The sunlight is absorbed by the panels, and then the infrared portion is trapped inside by the reflective gold or other metallic layers. These imprisoned rays build up intense heat, reaching temperatures over 1,000 degrees Fahrenheit (380 deg. C).

The heat is transferred to a liquid mixture of sodium and potassium flowing through the panels. This circulates through the coils in a huge vat of molten salts.

The salts act as an energy-storing reservoir, remaining hot through the nights and sunless days to provide a constant source of heat.

Water flowing in pipes through the salts is instantly turned into steam to drive turbines that, in turn, power generators to produce electricity.

The present solar power projects make use of the

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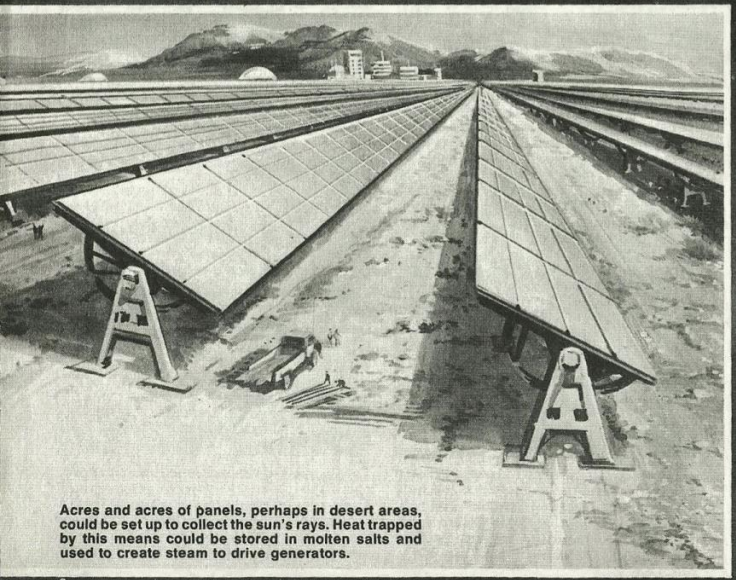
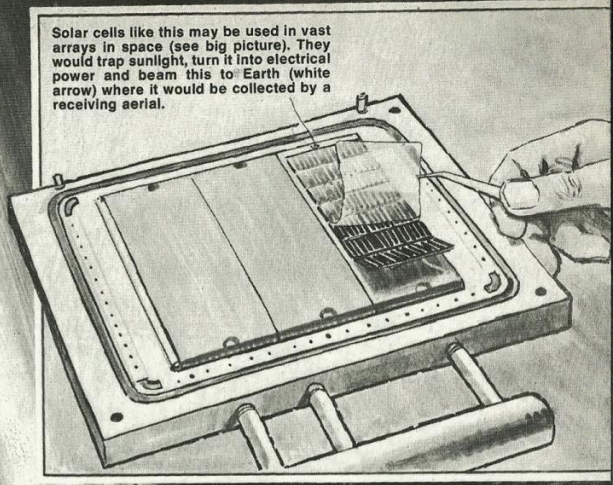


Acres and acres of panels, perhaps in desert areas, could be set up to collect the sun's rays. Heat trapped by this means could be stored in molten salts and used to create steam to drive generators.



Solar cells like this may be used in vast arrays in space (see big picture). They would trap sunlight, turn it into electrical power and beam this to Earth (white arrow) where it would be collected by a receiving aerial.

sun's energy falling on our planet. But some time in the next century we may be able to capture solar energy by space satellite. One scientist envisages huge collecting panels covered with solar cells which would turn the sun's energy into electrical power. This could then be beamed to Earth by microwave.

This is not to say the conventional ways of making electricity are doomed if methods can be found of doing this more cheaply.

As you probably know, electricity is made when an armature turns in a magnetic field. Considerable power is required to turn the armatures which operate the large generators.

But a way has been found of saving this energy. An American research worker, Dr. Arthur Kantrowitz, discovered hot, flowing ionized gas could be substituted for the rotating coils of which the large armatures are made.

He demonstrated this by directing the flame of a blowlamp, lightly salted so that it would conduct electricity, between the poles of a magnet. Current was picked up by the electrodes held in the flame, and conducted to a meter.

After the Russians had seen this idea demonstrated, they went home and poured money and effort into making a huge, working generator able to supply power to the grid.

They were successful, and the result is the U-25 MHD (MHD stands for magneto-hydro-dynamics) generator with a potential capacity of 25 megawatts.

Amid the chalets, meadows and snow-capped peaks of the Pyrenees lies another experiment in solar power, mentioned briefly at the start of this feature.

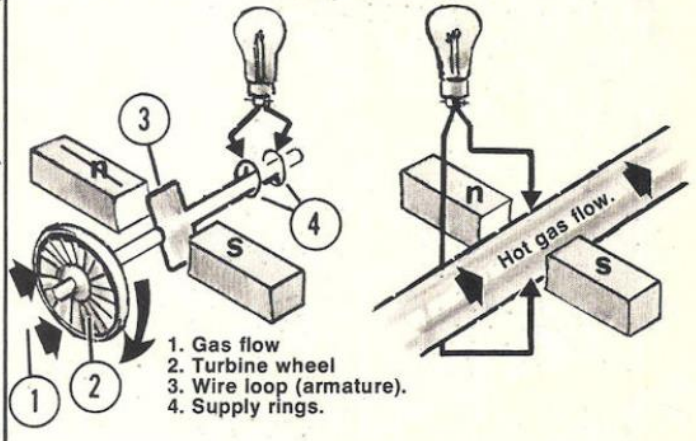
An enormous mirror focuses sunlight, reflected by banks of smaller mirrors, into a small furnace, creating a temperature of 6,000 Fahrenheit (nearly 1,600 deg. C.). This is hot enough to melt almost any substance on earth. In only one minute, it can burn a 12 inch (304 mm.) diameter-hole through thick steel.

With all these experiments, it is clear that the sun will not be allowed to burn wastefully in the sky for much longer. Soon it will be encouraged to shed sunshine on the world's fuel problems.

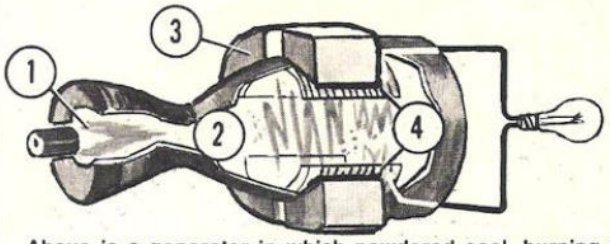
Fifty watts of power is produced by each of these panels of solar cells installed experimentally on top of a building in America. Their total output is 1,000 watts.

ELECTRICITY FROM GAS

Our diagrams show an ordinary generator (left) and a new one (right) in which hot gases flow between magnets to make electricity.

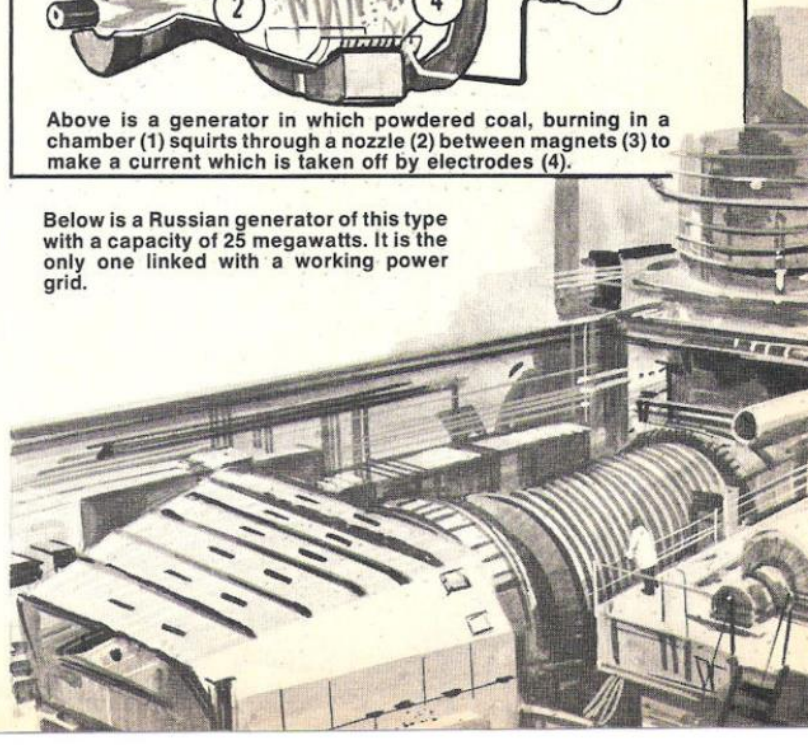


1. Gas flow
2. Turbine wheel
3. Wire loop (armature).
4. Supply rings.

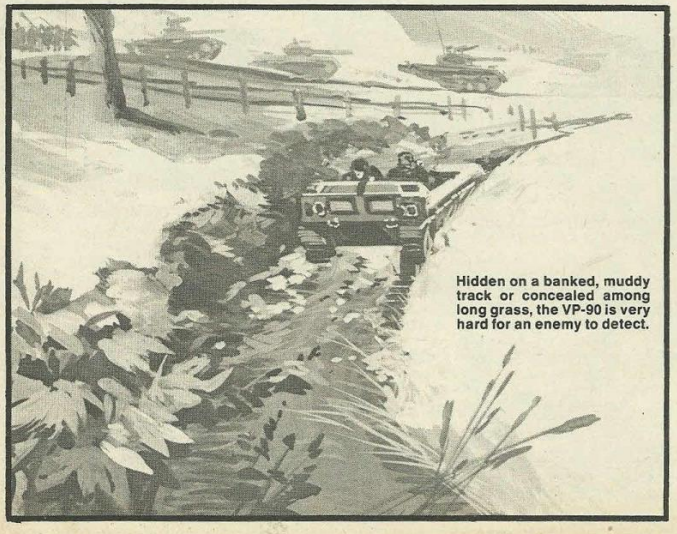


Above is a generator in which powdered coal, burning in a chamber (1) squirts through a nozzle (2) between magnets (3) to make a current which is taken off by electrodes (4).

Below is a Russian generator of this type with a capacity of 25 megawatts. It is the only one linked with a working power grid.



THE MILITARY MAID OF ALL WORK



Hidden on a banked, muddy track or concealed among long grass, the VP-90 is very hard for an enemy to detect.

BIG army tanks and mountainous military vehicles make easy targets for enemy gunners. In modern armies, the trend is towards small, fast and deadly vehicles that are both hard to see and difficult to detect by radar or infra-red devices.

Typical of this growing fashion is a new French tank, the VP-90, which is so small that you might be excused for thinking the VP stood for vest pocket (an expression once used to describe mini-cameras). It actually stands for *voltigeur patrouilleur* or light infantry patroller.

The VP-90 is a small tracked vehicle that stands just over a metre high. Powering it is a rear-mounted petrol engine, available in horse powers varying from 90 to 130 and capable of speeds of up to 90 km/hr (about 56 mph).

Making this high speed possible are four semi-automatic gears, rubber tracks reinforced with synthetic fibre and highly flexible suspension.

With its hull of ribbed sheet steel and an armoured front scuttle, the vehicle can do many jobs.

It can be used as a weapons platform fitted with armament varying from light machine guns to 20 mm cannon, from missile systems to 75 mm recoil-less guns, or from breech-loading 60 mm mortars to towed 120 mm mortars.

A new French tracked army vehicle is so useful that it can serve as an armoured attacker or as a life-saving ambulance.

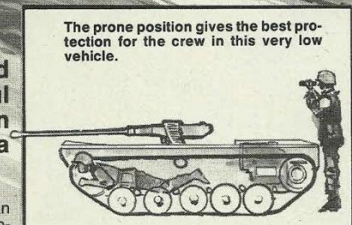
As a transport vehicle, the VP-90 can carry a driver and four men. For taking supplies to the forward lines, 600 kilograms (over 1,300lbs.) of material can be delivered. The VP-90 is also able to function as a command car carrying a driver, three men and a radio. And for rushing injured men to the military hospital, two stretcher cases with their attendant-orderly can travel at speed and in reasonable comfort.

In fact, the vehicle is so versatile that it could be called the infantry maid-of-all-work. Uses will be found for it in out-and-out combat missions, when its armament will make it an effective attacker.

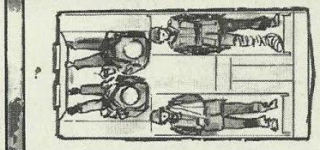
Because it is small and hard to detect, it should be ideal for reconnaissance and surveillance, and for carrying supplies to forward troops. As it plunges through a jungle or over rocky ground, it will be able to overcome obstacles by raising its nose nine degrees or lowering it four degrees from the horizontal.

Steering and braking are hydraulically assisted with a mechanical safety device. Enhanced by its small size, the VP-90 could be a deadly avenger in future wars and an effective deterrent to any potential aggressor.

In use by N.A.T.O. forces, it could play a valuable defensive role, and, despite its size, be highly effective in keeping the peace.

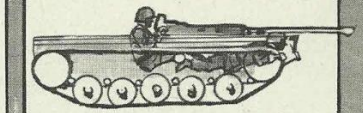


The prone position gives the best protection for the crew in this very low vehicle.

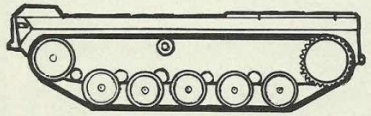


Two stretcher cases can be carried when the vehicle is used as an ambulance.

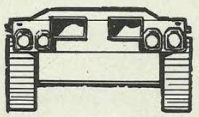
The VP-90 in its command post version with two look-outs on the alert.



With the driver prone, the gunner here is operating a 20 mm. weapon.



Seen from the side, the vehicle has tracks of rubber reinforced with synthetic fabric on alloy rollers.



Note the two armoured windows used when the crew is in the prone position.

LOOK AND LEARN

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THE TRAGIC QUEEN

See Inside

Launched from enormous mother planes, mini-fighters that defy detection by enemy radar could become effective deterrents against aggression by a potential enemy

Speed & Power

FREEDOM'S FLYING DEFENDERS

A SILVER giant screams through the skies. Suddenly, from its under carriage, there appear two trellis-type arms attached to a tiny fighter plane.

With a roar of its small but powerful jet engine, the mini-fighter tears itself away from its parent plane and swoops towards its target deep in enemy territory.

This could be a picture of warfare in the skies in the future, if plans being made in America come to fruition.

The U.S. Air Force has asked aircraft firms to design fighter planes small enough to be launched from a Boeing 747 transport plane, which should be able to carry ten of them.

Behind the request is the idea that the transport plane would take its fighters to the battle area, where they would be launched in the air one at a time.

If radar detectors warned the enemy of the fighters' approach, enemy fighters could set out to shoot them down.

To avoid this, the planes must be so shaped that they are hard for radar sets and other electronic devices to detect, and that they are visually difficult to identify. The designers have also been asked to consider what signals the planes could transmit to confuse an enemy's radar.

Proposals for various types of planes have been made. One idea is for a single-engined light plane which would fly at supersonic speeds when travelling to and from its combat area.

Six of these could be carried by the 747, as against the ten smaller fighters mentioned earlier. Launched from the mother aircraft, they could make three combat sorties before the mother aircraft returned to its home base.

Both America and Russia have had trouble in trying to perfect the technique of launching a plane in the air and recovering it. But the Americans say that to recover a fighter in the air should be no more difficult than routine air-to-air refuelling.

If this is proved correct, the way is open for a new and highly dramatic form of aerial warfare.

Six fighters of this type could be carried by a 747 transport plane. Each fighter would fly three combat sorties before returning home in its mother craft. Their speed is assured for their wings were originally designed for advanced supersonic transports.

LOOK AND LEARN

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THE SHE-WOLF OF FRANCE

SEE INSIDE

SWITCH ON TO A SATELLITE

This is something we may all do in the future if satellite power stations are put into orbit to turn the Sun's rays into electricity for use on Earth

REVOLVING in space midway between the Earth and the Moon in the no-gravity no-man's land, known to scientists as L-5, may be an amazing assembly of "flying saucers" towards the end of this century.

Looking like enormous car steering wheels hanging against the blackness of the sky, they will be power stations that convert the Sun's energy into electricity and send this to Earth in highly concentrated microwave beams.

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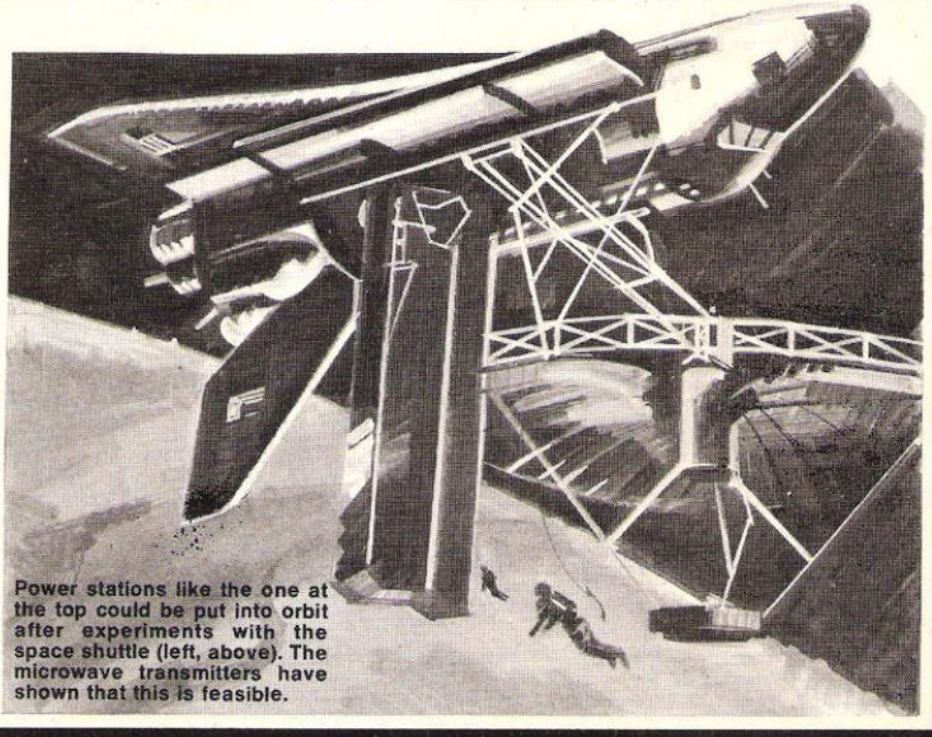
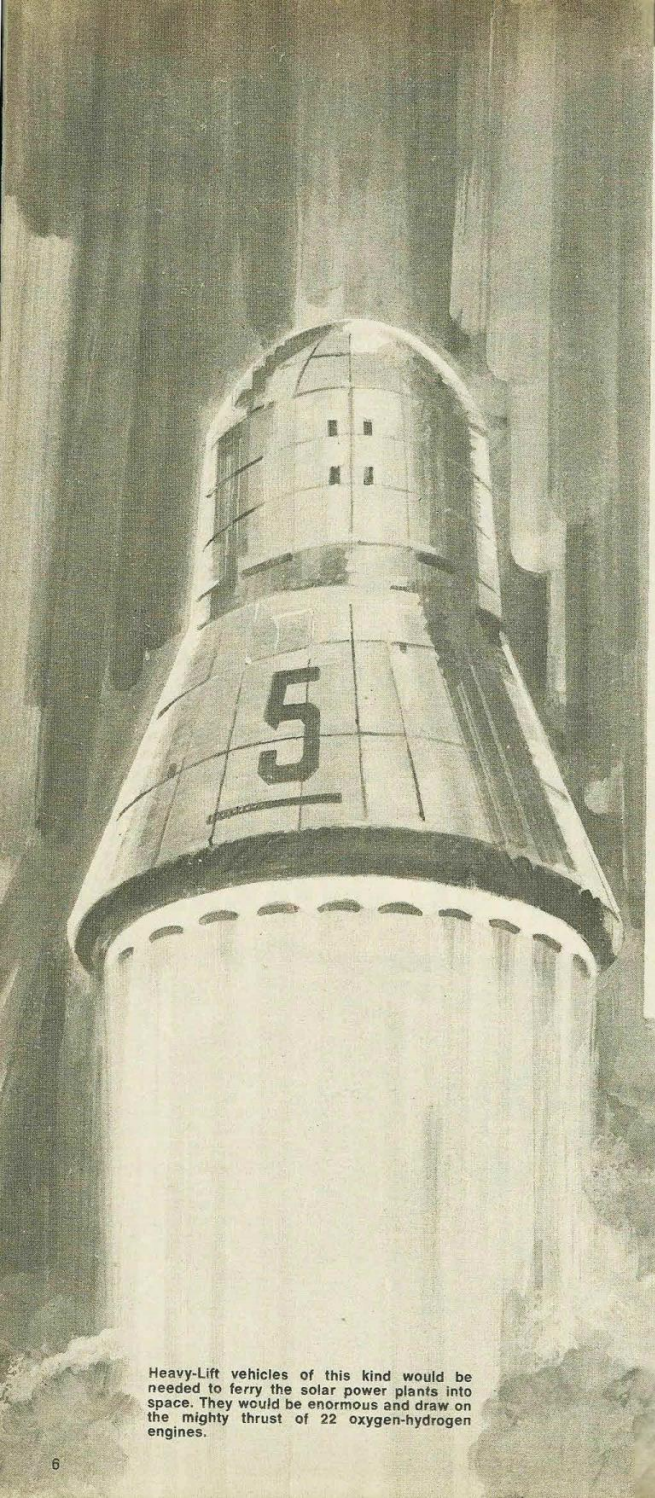
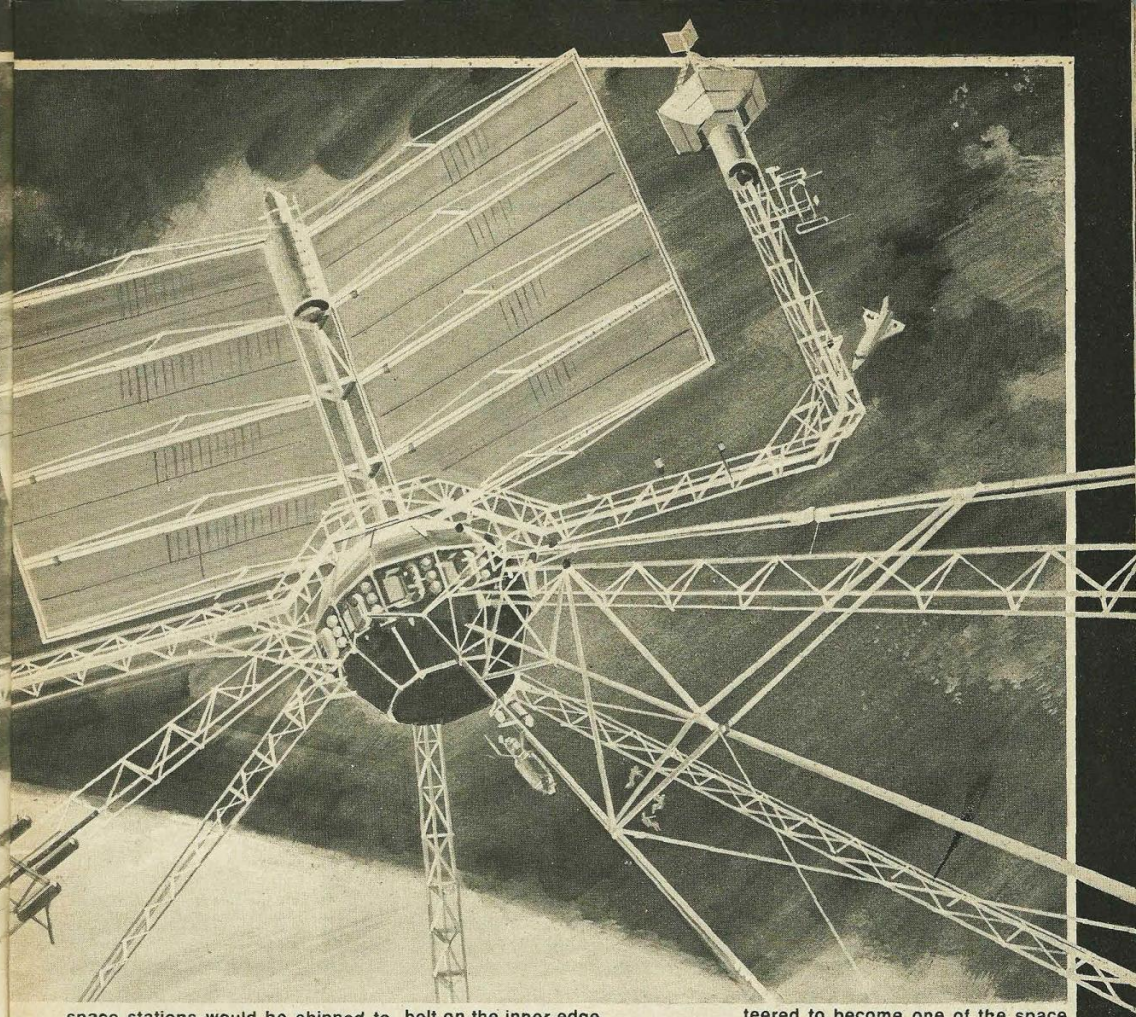


Power stations like the one at the top could be put into orbit after experiments with the space shuttle (left, above). The microwave transmitters have shown that this is feasible.



Heavy-Lift vehicles of this kind would be needed to ferry the solar power plants into space. They would be enormous and draw on the mighty thrust of 22 oxygen-hydrogen engines.

An artist's impression of part of a solar-electric power station. You can guess how big it is by looking at the docked shuttle orbiter (a kind of space plane) on the right. It is suggested that thirty stations like this could be put into synchronous orbit.



American space scientists have been looking towards the Sun as a source of power.

Unless the Earth is ready to make a gigantic switch to solar power by the turn of the century, we could be seriously short of fuel.

The arguments in favour of such a project are that solar power is pollution-free, cheaper than other fuels and inexhaustible.

With thirty of these orbiting power stations beaming their energy to Earth, a substantial contribution could be made to America's power requirements, saving the Earth's natural fossil fuels like oil and coal, say the space scientists.

One proposal is that these revolving power stations could be built in space. The Moon would be used as the halfway house, and from there all the prefabricated sections of the space stations would be shipped to their sites in L-5.

Special space freighters would carry the parts to the Moon or to an orbital assembly station.

When finished, the solar power stations would capture the Sun's rays with enormous metallized plastic mirrors. Solar cells would turn this into electricity which would be converted into microwave energy in high-power electron tubes.

This would be beamed to Earth where receiving stations would turn it into power for distribution through the existing power grid.

Eventually, space stations more than a mile in diameter (over one and a half kilometres) could be revolving in space. Homes for ten thousand people could be built into the rim. These would house the technicians, whose job it would be to keep the solar power station working. Their food would be grown in an agricultural belt on the inner edge.

"It may be mind-boggling, but establishing a colony of ten thousand people would be straightforward," says John F. Yardly, associate administrator for space flight for the National Aeronautics and Space Administration.

"It could be done by 1990 if there was enough support."

The ten thousand colonists could move into Solar power Station No. 1 by 1998.

Dr. Thomas Heppenheimer, a leading American planetary research scientist, says, "The time is not far away when young construction workers will be browsing through notices of employment opportunities at L-5.

"There is absolutely no reason why the next generation should not spend their entire lives in space and be happy to do so."

This is not empty talk, for Dr. Heppenheimer, who is 29, has volunteered to become one of the space pioneers.

Not all solar power stations will be shaped like steering wheels in space. Some will consist of an array of mirrors with their solar cells and microwave transmitters supported on trusses that make them look like spiders of tremendous size.

Enormous heavy-lift vehicles will be needed to ferry this equipment into space. But there is no doubt that the nation which put the first man on the Moon could also overcome any of the problems that stand in the way of establishing a ring of power stations in space.

As each of the space power stations will be equal in output to two of the largest conventional power stations now in use, their contribution to the world's energy resources will be big enough to make the solar power project a valuable undertaking for scientists in the near future.

THE WORLD'S AIR ACES ON DISPLAY

Many of the world's most exciting aircraft will be taking to the skies this weekend for the International Air Tattoo 76. Among the highlights of the display will be the demonstrations of aerobatics given by some of the world's leading service pilots

The sky over the RAF station at Greenham Common, near Newbury, Berkshire, will be alive with aircraft this weekend when the International Air Tattoo is to be held on Saturday and Sunday, July 31st and August 1st.

Well over 170 aircraft from 20 international air arms will be taking part in the display. On both days there will be more than seven hours of flying exhibition.

No fewer than six national aerobatic teams will be giving examples of their superb precision flying, showing off the timing and co-ordination that takes years of work and practice to perfect. The teams taking part will be the RAF's Red Arrows, the Patrouille (Patrol) of France in their Fouga Magisters, the Frecce Tricolori (Tricoloured Arrows) of Italy, flying Fiat G-91 PANs, the Yogi-Mike Starfighter team from Canada, the newly-formed Austrian Air Force Silver Birds team in SAAB 105s, and the Belgian Diables Rouges (Red Devils), also in Fouga Magisters.

Another highlight of the weekend will be the competition for individual aerobatics, in which service pilots will be going through their paces for the Embassy Jet Aerobatic Trophy. On the two previous occasions that this competition was held the winners were RAF pilots, and this year's entries include six pilots from the RAF who are hoping to make it a hat-trick of victories. But they face fierce competition from among a record entry of 20 planes from ten different air arms.

Fighting for the trophy will be some

CONTINUED ON NEXT PAGE ▶

Above we see just 14 of the 80 or more different types of aircraft to be seen flying or exhibited on the ground at the Air Tattoo.

1. General Dynamics F-111E (U.S. Air Force)
2. Saab 105 OE (Austrian Air Force)
3. Supermarine Spitfire (RAF Battle of Britain Memorial Flight)
4. Breguet Atlantic (Royal Netherlands Navy)
5. Aeritalia G91 PANs of the Italian Air Force's nine-plane aerobatic team
6. Hawker Hurricane (RAF B of B Memorial Flight)
7. Hawker Siddeley Harrier (RAF)
8. Hawker Siddeley Hawk (RAF)
9. Lockheed F-104G Starfighter (German Navy)
10. Northrop F-5E Tiger II (U.S. Air Force)
11. SEPECAT Jaguar (RAF)
12. Avro Lancaster RAF B of B (Memorial Flight)
13. Boeing B-17 Flying Fortress
14. Grumman F-14 Tomcat (U.S. Navy)

One of the show's features will be a celebration of the first flight of the Hawker Hunter 25 years ago. The first prototype will be on display with 25 later Hunters.

Speed & Power

THE PRICE OF PEACE

Whatever peace costs it is cheap at any price, think the Americans who have sunk a fortune in creating a force of mammoth ships able to land a battalion of men and tanks at any trouble spot

PEACE is costly for the superpowers. It is especially so for the Americans, who are spending fortunes in maintaining armies and armaments mighty enough to deter any aggressor.

One of their latest investments in peace is the mighty vessel you see in our pictures.

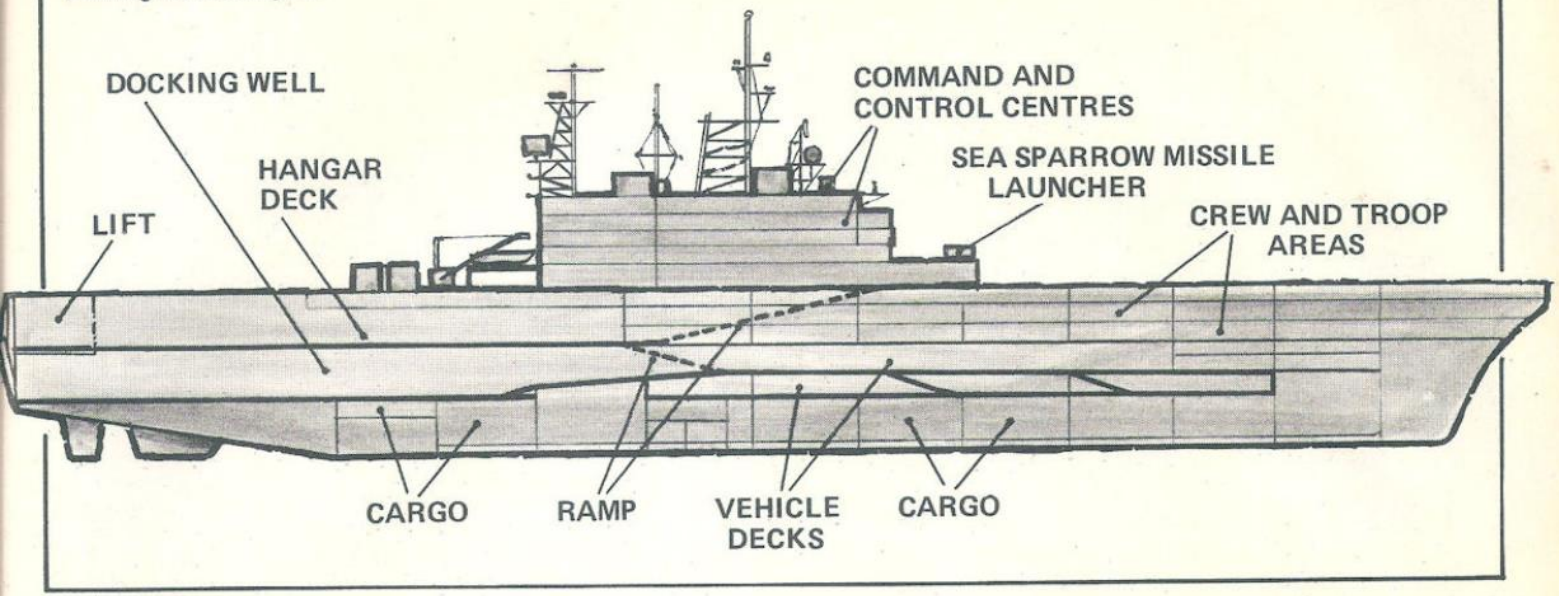
CONTINUED ON NEXT PAGE►

Ready for battle, soldiers race up an enemy beach with armoured vehicles close behind them.

Only slightly smaller than a modern aircraft carrier is the new American LHA assault craft (above) which is able to launch helicopters and landing craft which carry men and supplies ashore.

Tanks, vehicles and artillery are carried in parking spaces, from which they are taken by lifts and ramps to the landing craft.

A cutaway drawing of the LHA showing the deck layout.



It is an assault craft that has a flight deck, longer than two football pitches, for helicopters and jet planes. Simultaneously, it can launch troops and tank-carrying barges from its stern, which opens up at water level.

This mammoth assault craft is as high as a twenty-storey tower block and carries a crew of 800.

Its cost is 231 million dollars, which is about 135 million pounds.

A DEADLY DETERRENT

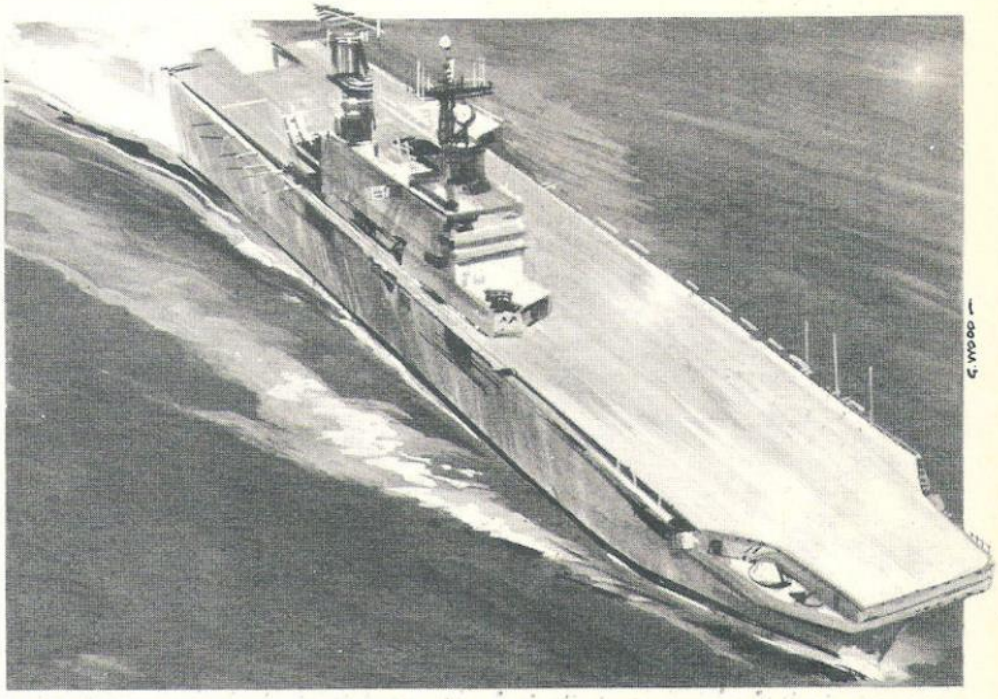
Designated LHA for Landing Helicopters Assault, it can attack an enemy with guns, planes, tanks and troops in one massive, mighty blow. And if that is deadly enough to make any warlike enemy think twice about attacking the U.S.A., then its purpose will have been fulfilled.

America's decision to build five of these craft was made because of the reduction in permanently-based overseas forces and the need for a fast, mobile strike force that could hit anywhere from long range.

A combination floating airfield, mobile military base, troopship and high-speed amphibious assault vessel all rolled into one, the LHA can be sent to any part of the world where U.S. forces are needed.

Named the *U.S.S. Tarawa,* the first LHA will be able to launch nine giant troop-carrying helicopters at a time. As soon as these are in the air, a second wave of nine more can be sent off, followed by still another. These helicopters will be either Sea Knights or Sea Stallions which carry 17 and 36 soldiers respectively, or vehicles and artillery.

Apart from the helicopters, the LHA can launch jet aircraft such as the AV-8 Harrier, the famous British jump-jet.



Seen undergoing sea trials is the first of America's Landing Helicopter Assault craft (LHA), the *Tarawa*. Altogether, five such ships are to be built.

While the helicopters or jets are being launched, a well in the stern would be flooded to bring the inside water-level up to that of the sea. Then the stern would be opened up and out would swarm streams of landing craft, heading for the shore.

Tanks, armoured vehicles, guns and other equipment, moved by a system of ramps and lifts connecting the various deck levels, would be loaded on to the waiting landing craft and taken ashore. While more and more troops, supplies and landing vehicles were being ferried ashore, the troop-carrying helicopters would be repeatedly returning and re-loading with fresh men and materials.

At the end of the operation, the LHA will have landed an entire 1,800-man armoured battalion on an enemy beach.

For its own protection, the LHA will carry three 5 inch (127 mm.) deck guns, six 20 mm. machine guns and two 8-cell rocket launchers that fire the Sea Sparrow anti-aircraft missile.

All of the LHA's operations will be controlled from a central tower, packed with the latest computer and communication equipment to ensure that the attack on the enemy is fully co-ordinated.

Two giant steam turbines with the combined power of 700 average-sized cars (140,000 hp) will propel the ship at 20 knots towards its battle area, where it could soon prove to an aggressor that peace is preferable — and cheap at any price.

LOOK AND LEARN

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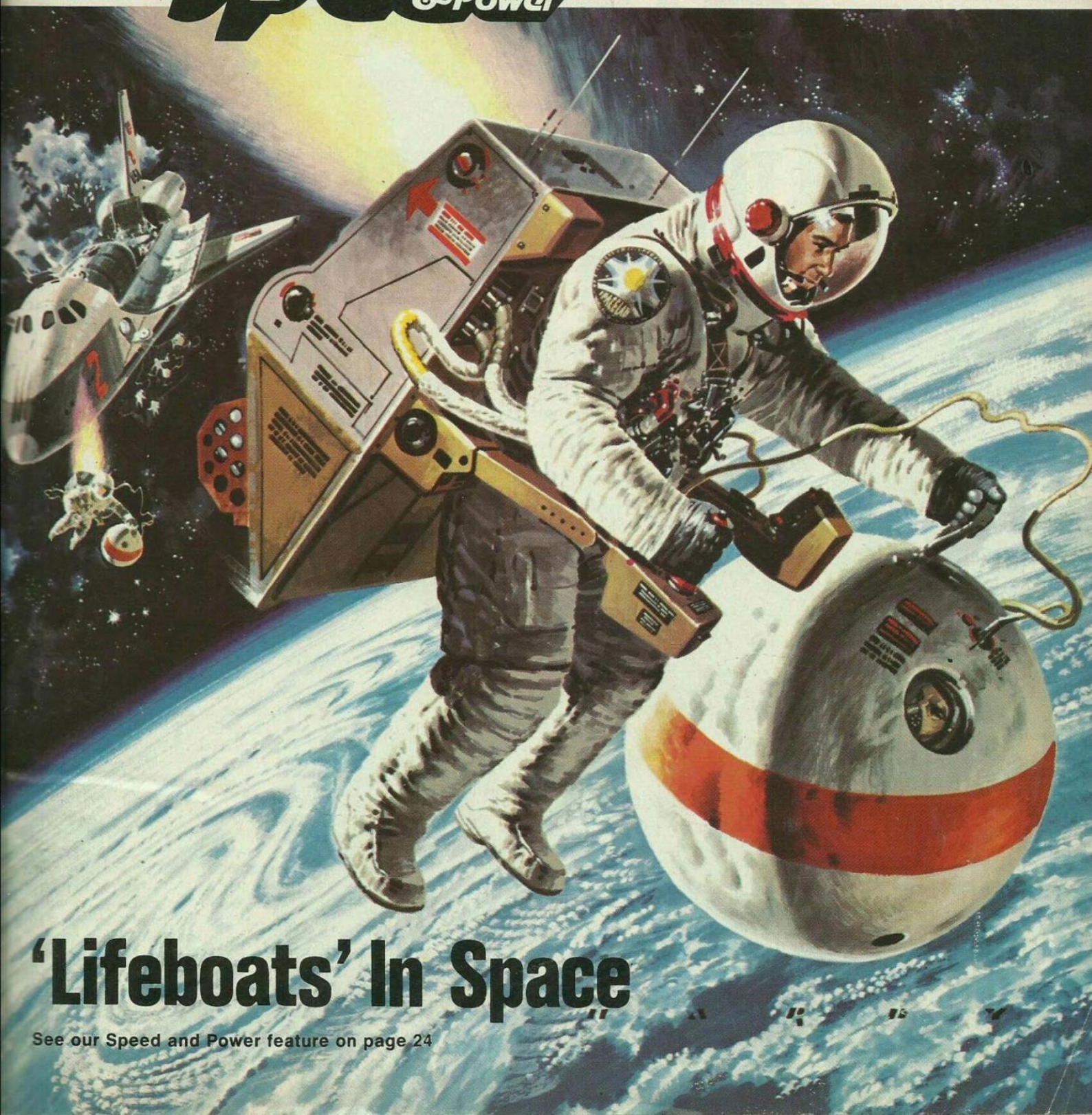


'Lifeboats' In Space

See our Speed and Power feature on page 24

'LIFEBOATS' IN SPACE

When the next stage in space exploration gets under way in a few years, scientists at work in the heavens may be rescued from damaged craft in remarkable oxygen-filled spheres

BIG things are happening on the space research scene. Costly rockets that are left to burn up in space, and fabulously expensive orbiting laboratories like the American Skylab and the Russian Salyut that are lost in the limbo of the universe, are destined to become historical curiosities.

When the Americans next go into space in 1979, it will be in a vehicle that is more like a space liner than the spacecraft of the past.

This is called a space shuttle. It will blast off on the power of two solid-fuel rockets which, at a height of 28 miles — 45 km — fall away on parachutes and drop in the sea, from which they are recovered.

Just before the shuttle goes into orbit, its huge fuel tank will fall towards the Earth and get burnt up in the atmosphere.

But remaining in orbit will be the winged shuttle, like the ones shown in our big picture, with its own smaller rockets in its tail.

Scientists can work in these, for some of them are big enough to house huge laboratories. And they can then return to Earth in them, for the wings on the shuttle will enable it to fly back to its home base, protected by its massive heat-resisting insulation.

In fact, the space shuttle will be much more like a space airliner for the scientists, with three trained space pilots to operate it.

Like any other airliner crew, they will be responsible for the safety of their passengers, probably a maximum of four.

The scientists will be space men only in terms of getting used to such problems as working, eating, showering and sleeping in weightless conditions.

Should they have to be transferred from a damaged craft to a rescue craft, they may be carried in a rescue ball, now being developed.

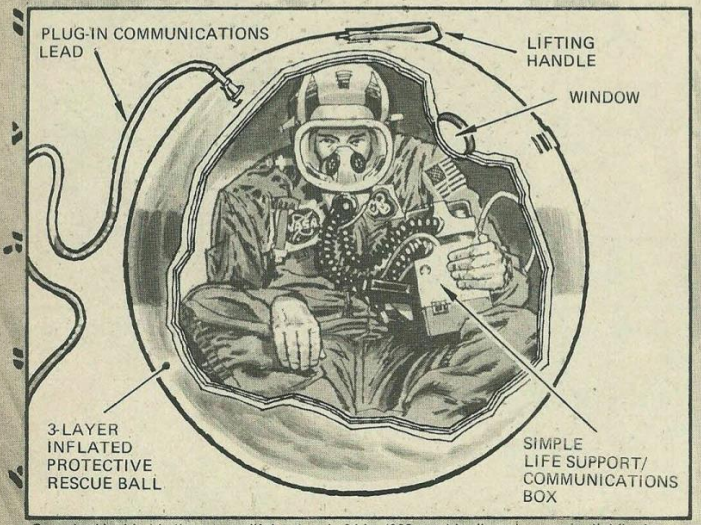
Aided by space-suited crewmen, they would be zipped inside the tiny spheres, with breathing and communications equipment in a small box. The balls would then be sealed, inflated and transferred by the spacemen to the rescue craft.

The outer layer of the sphere would, like that of a space suit, be protection against the blistering heat of the sun, unfiltered by the Earth's atmosphere.

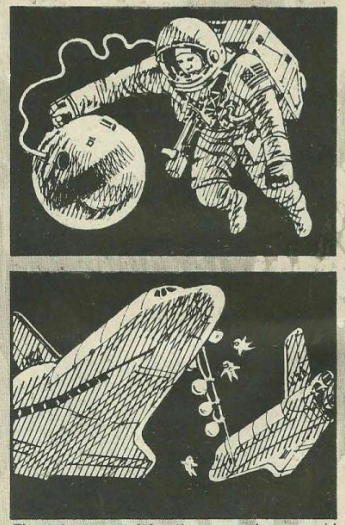
The picture on our cover and the main illustration on these pages show scientists being transferred from a damaged craft to the rescue vehicle, which is in the foreground on the right.

All this is not so far into the future as it seems. The first space shuttle orbiter should be glide-tested on the back of a modified Boeing 747 jumbo jet next year. And the second prototype could make the first flight into orbit in 1979.

After that it will be no-holds-barred for the next stage in Man's exploration of the universe.



Crouched inside his tiny space lifeboat, only 34 in. (863 mm.) in diameter, a scientist floats through space towards the rescue vehicle. The sphere was inflated with oxygen from the shuttle system after the man had zipped himself into it. With him he takes an oxygen bottle to provide an additional supply, should this be necessary. The sphere's cover protects him from the intense heat of the sun.



The sphere containing the rescued man could be towed across the sky by an astronaut (top picture) or pulled across on a line rigged between two space ships (above). The most effective method would be chosen.

LOOK AND LEARN

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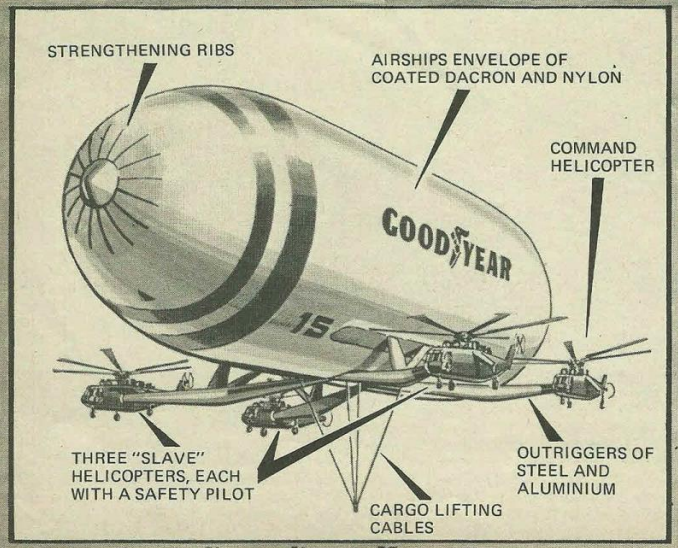
THE LIGHTWEIGHT HEAVYWEIGHT LIFTERS — SEE INSIDE



DYNAMIC DUOS

Helicopters and airships may not seem as natural a partnership as bacon and eggs or Laurel and Hardy, but some American and British scientists think otherwise . . .

IMAGINE combining the lifting power of a big airship with the lifting power and *precise control* of a helicopter. That is what experts in America and Britain are planning. It is a brilliant concept, and an American idea — one of several being considered — is shown above and on the left.

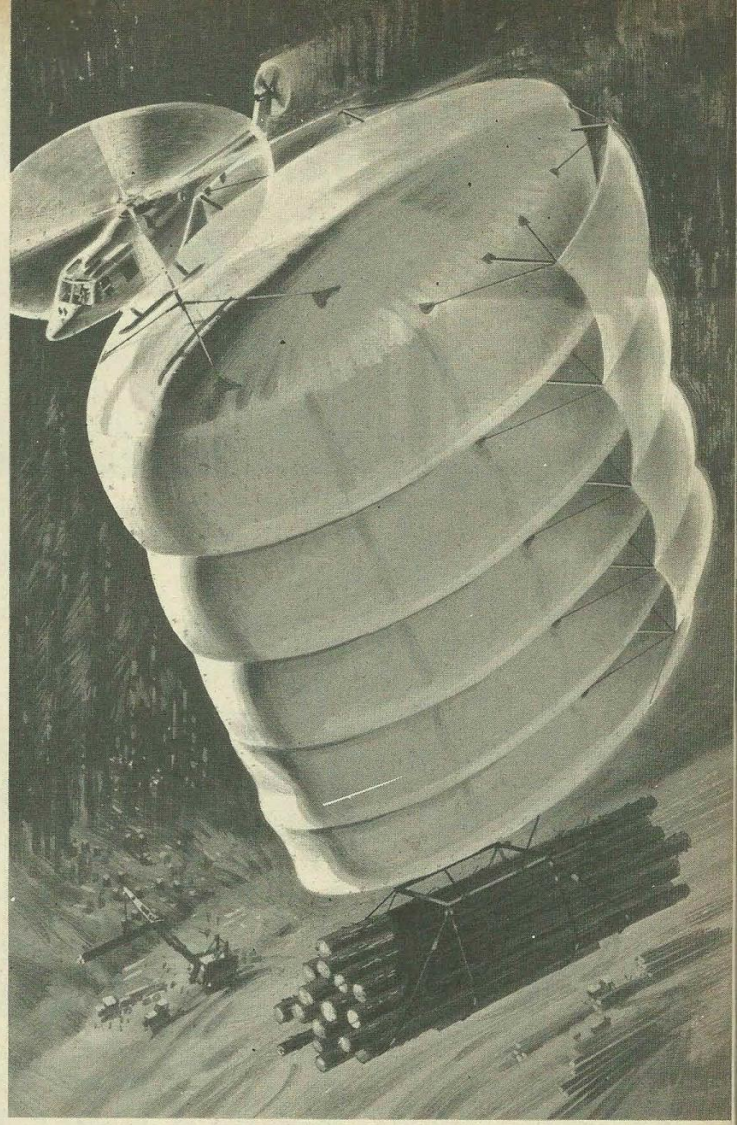
The American heavy-lift airship — HLA for short — could lift payloads of several hundred tons, while considerably lessening the problems of low-speed control, hovering in cross winds, mooring, landing, ground control and ballast/load interchange.

The buoyant weight of the big hull will offset the empty weight of the vehicle, leaving the rotor thrust available for lifting payloads and manoeuvring the vehicle.

The HLA will have a civil as well as a military use and a typical civil project could be to move payloads for oil drilling firms, heavy building or mining.

The scheme originated with the Piasecki Aircraft Co. (Piasecki being a famous helicopter pioneer). The airship will be flown using standard helicopter controls, and a safety pilot in the command helicopter, and each of the "slave" helicopters, as they are called, will retain mechanical controls in case of emergencies.

All this lies in the future, but, as we know, the future can materialise very swiftly in the field of aeronautical engineering.



BRITAIN'S projects are being developed by Professor I. C. Cheeseman and Lieutenant Commander D. R. Taylor at Southampton University, one of their ideas being shown above. It is called SLAB (Static Lifting Aerodynamic Body) and is a large upright semi-rigid gas bag shaped like a thin oval in cross section. In our artist's impression it is shown working with a Westland Lynx helicopter, hauling timber. Under the best conditions this combination could lift and transport about ten times the load that the helicopter could manage. The lifting gas would probably be steam, which is twice as efficient as hot air in lifting and is easily controlled to adjust the airship's descent. A combination of steam and helium might also be used.

The design shown has fins or "sails" fitted to keep it stable in flight. It is built with a light framework which will collapse flat like a Venetian blind on the ground, and allows for an easy stage-by-stage inflation and deflation. One of the problems of handling airships on the ground is to control them in sudden wind gusts. The SLAB has no problem. It can be quickly deflated. If a light load is carried, the lower sections can be lashed flat to the upper inflated area.

LOOK AND LEARN

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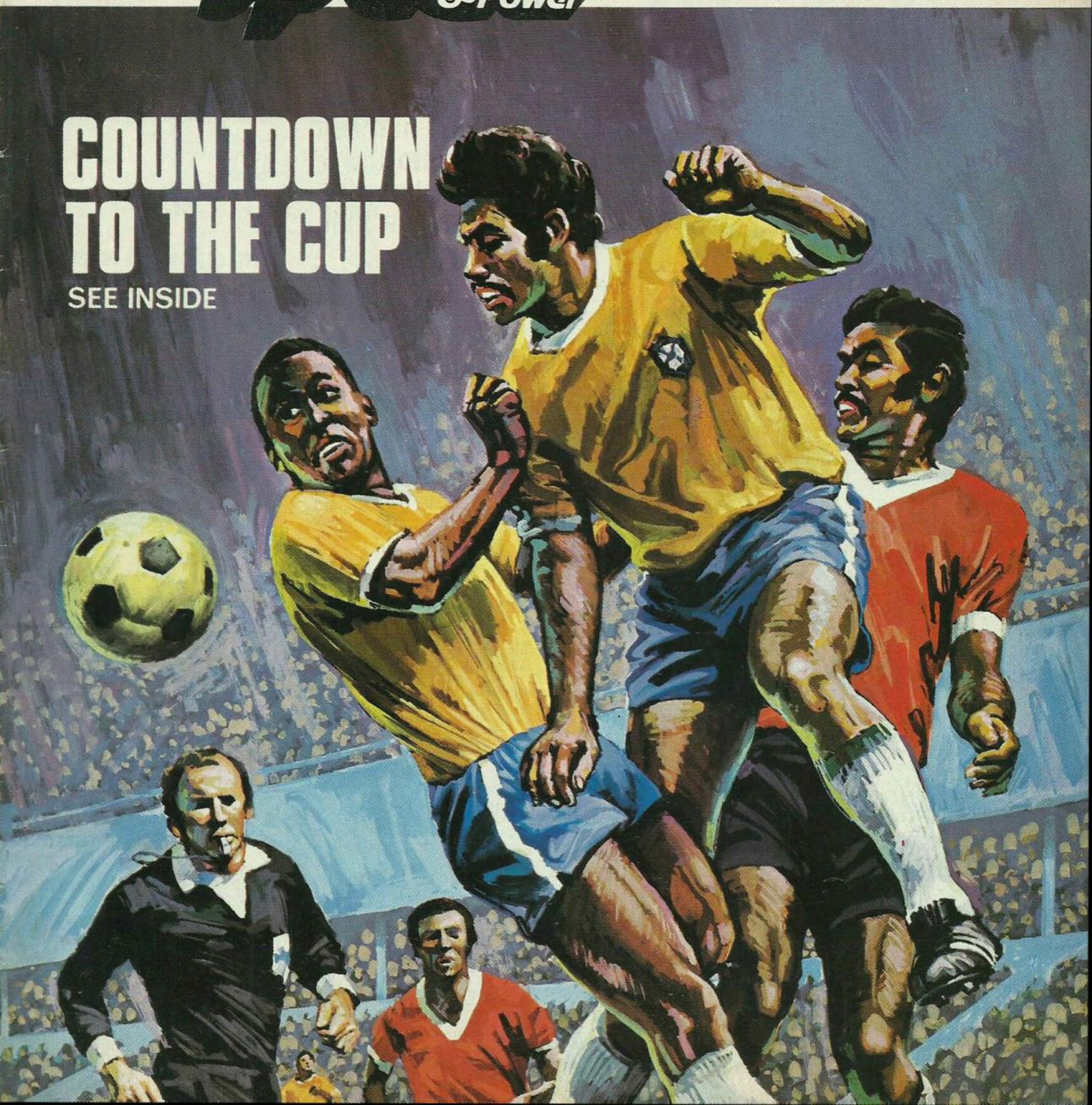
COUNTDOWN TO THE CUP

SEE INSIDE



Speed & Power

SAILING THE SEAS —IN A TRAIN

The costly handling of cargo at the ports is being sidestepped by a long distance ferry ship which is pioneering a new route between Germany and Finland

WHEN one thinks of railways it is natural to assume that they are strictly a form of land transport, but there are times when it is advantageous for trains to cross the sea. This can only be done, of course, by using train ferries — specially designed ships on to which trains can be run straight from railway lines to the dockside.

Railways are still one of the world's biggest carriers of manufactured goods and raw materials, such as coal and the various natural ores needed by industry. Unless the "container" system is used, these goods have to be unloaded when they arrive at a seaport, loaded on to a cargo vessel, and then unloaded again when it reaches its destination. All of this takes time and necessitates large storage sheds in the dock areas. Consequently, carrying loaded railway wagons on a ferry is an obvious advantage.

Most of today's train ferries, like those that operate across the English Channel, are comparatively small vessels, and they have only to travel the twenty odd miles between Britain and the continent of Europe. Last year, however, a new, giant rail ferry began making voyages of over 500 miles (800 km.).

This huge ferry is named *Railship 1*, and it carries fully

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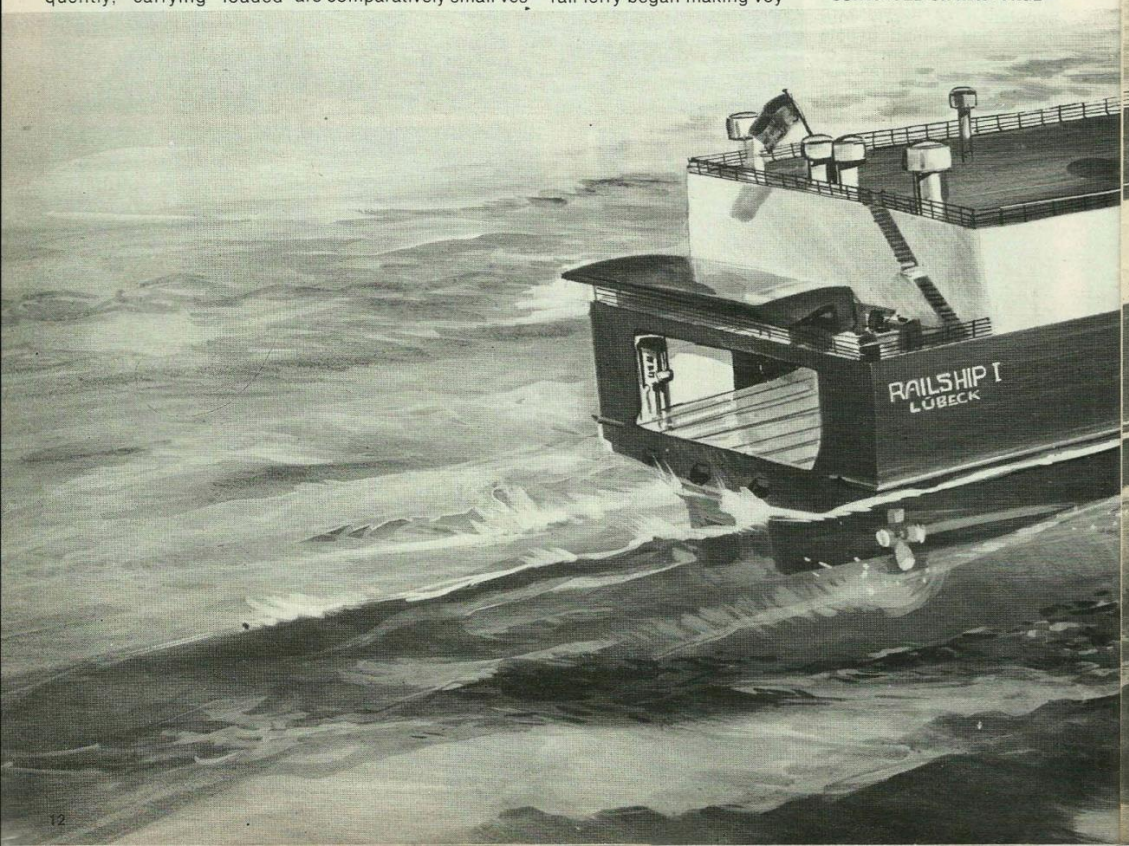
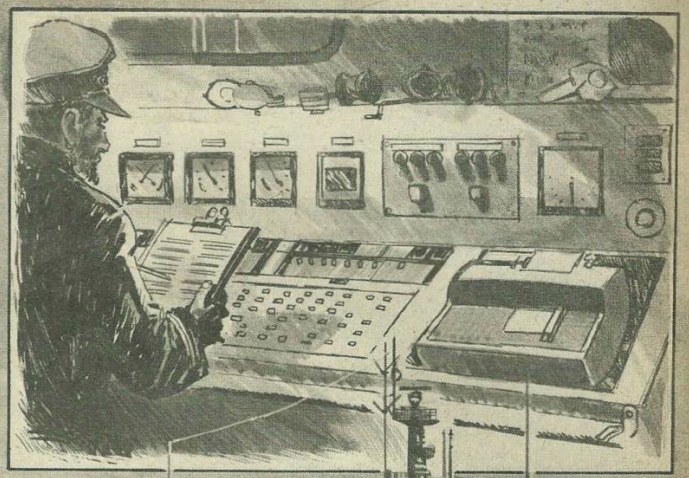
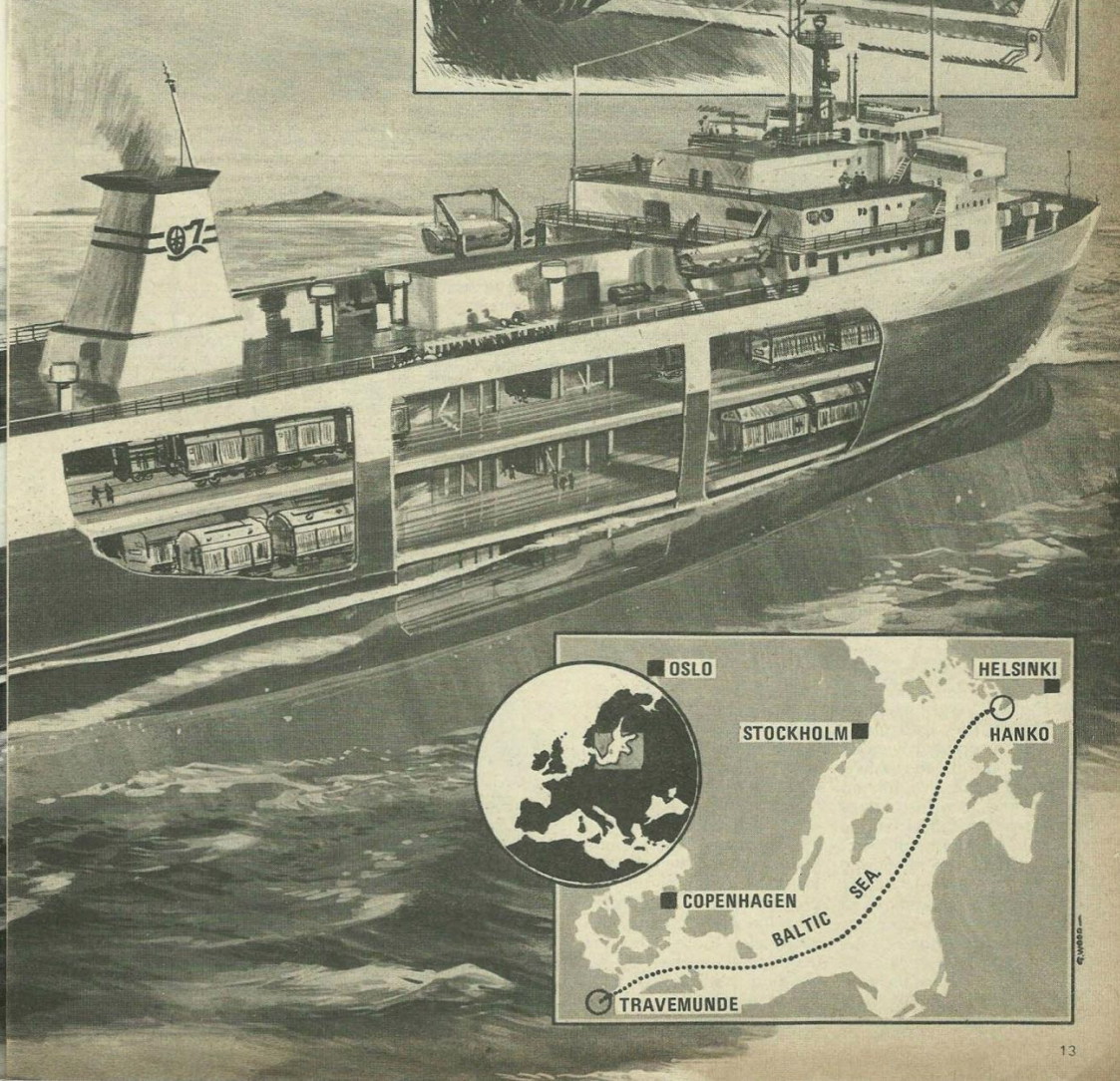


Built in Germany, *Railship 1* can carry up to 60 freight wagons on three decks. It is controlled from a main console (right) which includes an alarm system and an alarm recorder. These warn the captain of any emergencies in the unmanned train decks below.

The main features of *Railship 1* are shown in the cutaway picture below. Loaded wagons are run on to the vessel through the hinged door in the stern. Five sets of rails are recessed into the deck. A lift transfers the waggons to the upper or lower decks.

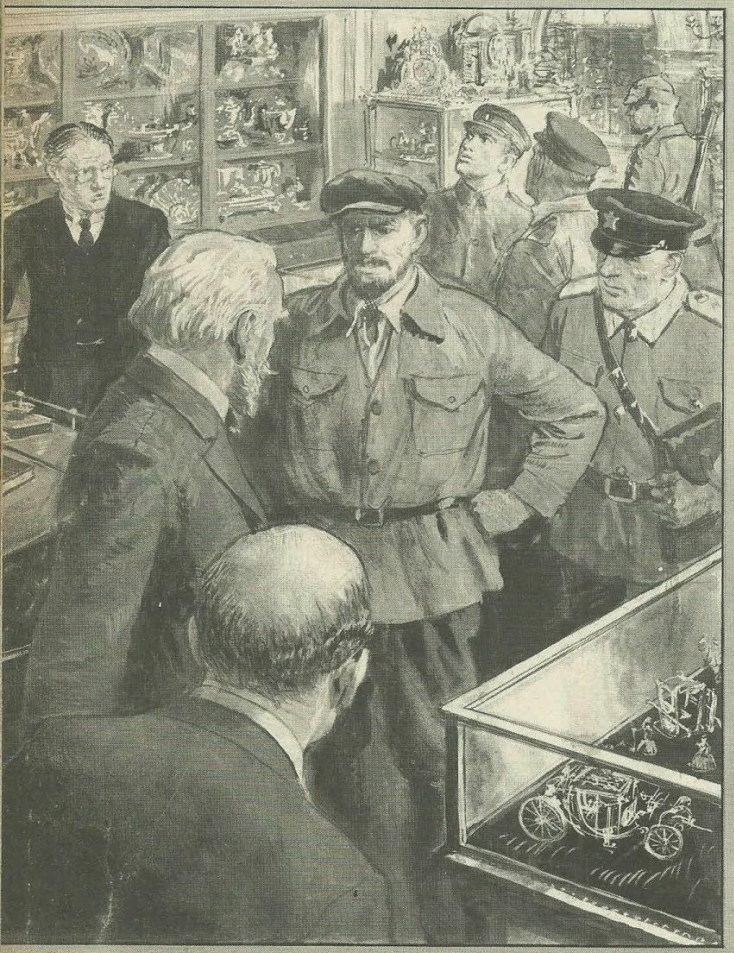




TOP OF ITS CLASS

GENIUS WITH A GOLDEN TOUCH

"Any fool can buy a diamond," said Carl Fabergé, Europe's most skilled craftsman jeweller. But only a person of taste would appreciate the exquisite beauty of a masterpiece fashioned by Fabergé in gold and precious stones



"These premises are now the property of the State," the Russian revolutionaries told Carl Faberge, who silently put on his hat and coat and walked out of the shop.

Faberge was put under the wing of a Finnish craftsman (above, left) who spent years teaching him the secrets of his craft.

For the Tsarina, Faberge fashioned a delicate and beautiful Easter Egg which opened to reveal a tiny chicken and a miniature crown.

AT the height of the Russian Revolution of 1917, a party of Communist officials made their way to 24, Marskaya Street, in what was then St Petersburg, now the city of Leningrad.

The building they approached was clearly a shop of some kind, although the plate glass windows were curtained and empty. Only the name, *Fabergé*, announced that this was the headquarters of the most famous jeweller in the world.

The revolutionaries marched in, staring about curiously at the glass-topped counters and long, shallow showcases. Possibly, they found themselves thinking that this was the shop which the greatest nobles in the land had been accustomed to visit, an establishment that catered only for customers who could command the very best. Certainly, a few months earlier, it would have seemed impossible that they might even have entered such a place. Now they looked grimly at the man who sat beneath a large clock at the far end of the showroom and called him by his Russian name.

"Karl Gustavovitch Fabergé?"

The man inclined his head. He looked younger than his age, which was 72. Bearded and distinguished, his unexpectedly casual clothes made him look more like a university professor than the head of a thriving commercial enterprise.

"These premises are now the property of the State."

Carl Fabergé nodded again. Since private businesses were to be outlawed in the new Communist Russia, he must have been expecting something of the kind.

"May I have a few minutes in which to fetch my hat and coat?"

The official nodded blankly. In theory, under the new rules, the one-time owners of business houses just went on working as though nothing had happened, but apparently this man had different ideas. Silently Fabergé put on his hat and coat and walked out of the shop without a backward glance. If the revolutionaries wanted his business they could have it, but they were not getting the man who had made it. If the old Russia had gone, then Carl Fabergé would go as well.

Nobody will ever know what the master craftsman thought as he trudged through the snow-covered streets of St Petersburg, but it would hardly have been surprising if he had reflected that the story of his family was beginning to repeat itself. It had been in 1685 that King Louis XIV of France had turned against the Protestant subjects and driven out nearly half-a-million of them to make lives for themselves somewhere else.

The Fabergés had been one of these refugee families who had paid money to one of the many "guides" who had made a business out of smuggling Huguenots out of the country.

They made their way to Russia, where one of them, Gustav, became a famous goldsmith. His son, Carl, was educated in Germany and then put in the care of a Finnish craftsman who spent years passing on to his pupil the technical secrets of a lifetime spent at the work bench.

When young Carl had nothing more to learn, he was sent to each of the major European countries in turn in order to study the work of foreign craftsmen. Then, when he was 24, he returned to Russia and took over complete control of the family business.

Within a few years, what had been no more than a respected jeweller's was spoken of in the world of art with some-

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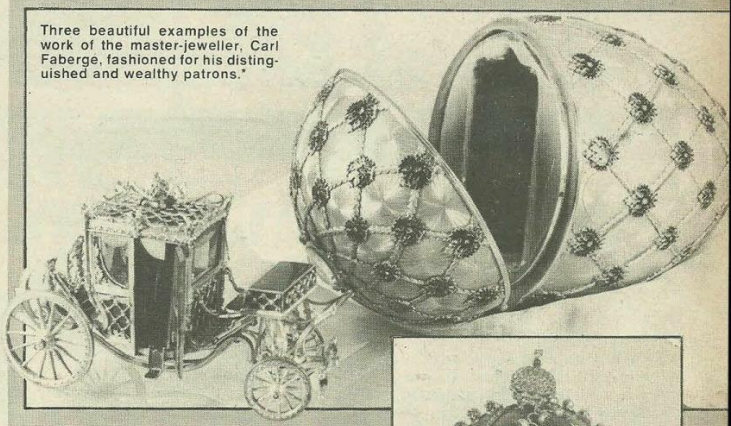
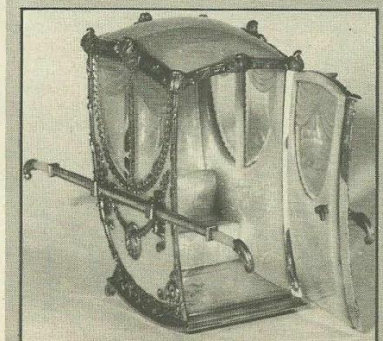
Three beautiful examples of the work of the master-jeweller, Carl Faberge, fashioned for his distinguished and wealthy patrons.*





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SANTA LANDS ON MARS!

See page 2

EXPLORING SPACE

PART TWO OF THIS SPECIAL

Speed & Power SERIES

ROBOTS AMID THE UNIVERSE

Spacecraft from Earth will explore the farthest corners of the solar system if America's ambitious and enterprising space programme becomes a practical possibility. But the explorers will be unmanned robots dependent upon Earthbound humans for their commands.

THERE will be a strange familiarity about the television pictures received of the first men on Mars. Bulky, space-suited astronauts will lumber around a bleak, arid plain, occasionally driving off in a small electric "jeep" from their landing craft, of which the upper part is an ascent stage, to carry them back to their mother craft orbiting above.

This could have been happening even as soon as the early 1980s if the money had been available. Now indefinitely shelved, the plan represents an ambitious scheme involving two identical nuclear-engined spaceships each crewed by six astronauts.

The two-year journey was to have included six months in Mars orbit while three of the crew from each ship spent half that time on the surface. The one-year journey home was to be by way of Venus.

The shortest route from Earth to Venus, now well travelled by a number of spacecraft, takes about four months. Mars, our next nearest neighbour, is about six months' minimum travel time away. This means that they are both reasonably accessible with the use of a simple interception trajectory.

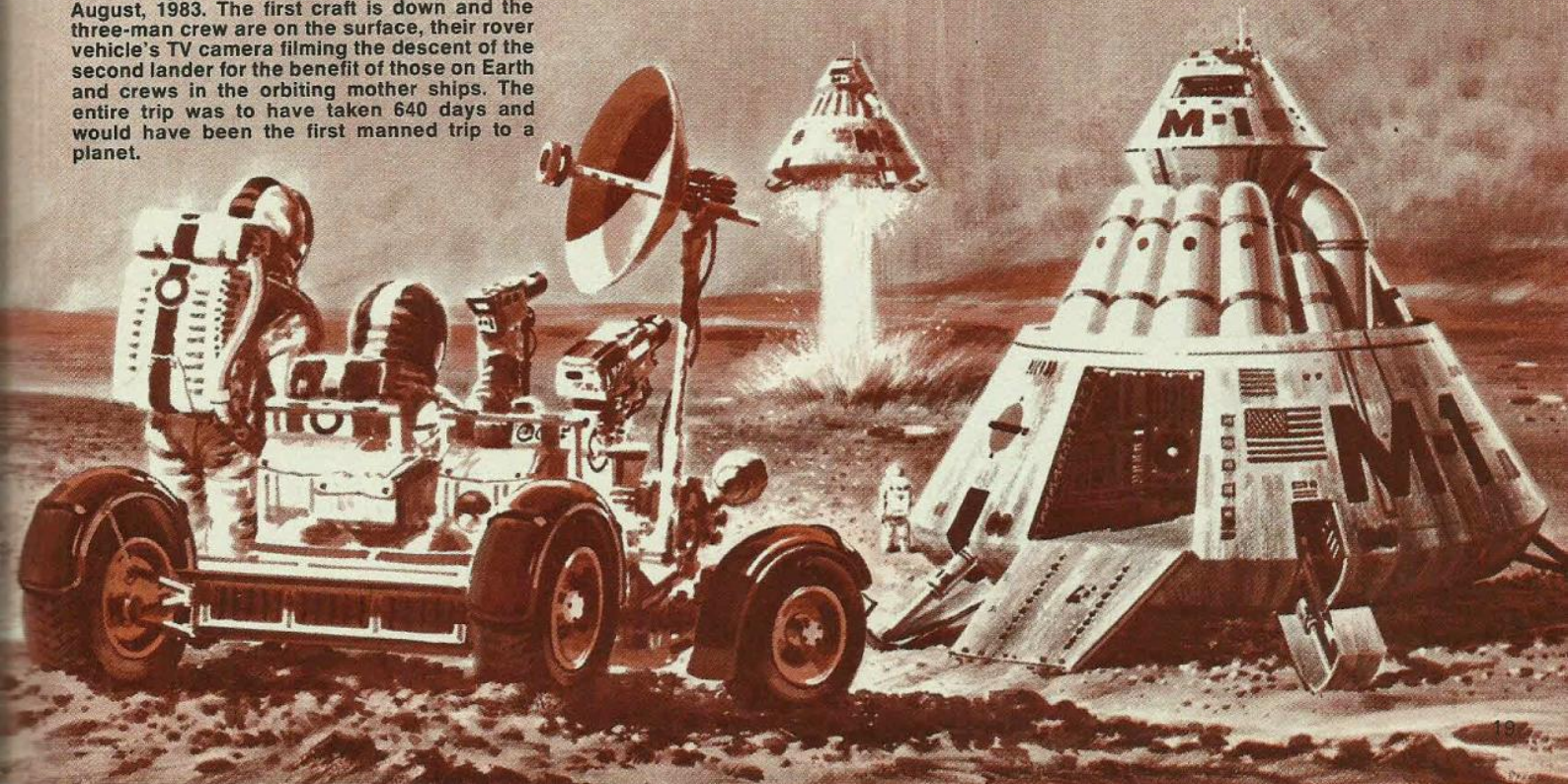
Put another way, flights to Venus, which lies inside the orbit of Earth and closer to the Sun, involve firing a rocket backwards along the path of the Earth. The spacecraft then slows down in relation to the Earth and arcs inwards towards the Sun until it crosses the orbit of Venus just when the planet reaches the same point in its orbit. To reach Mars, the opposite must happen, the craft being fired ahead of the Earth. Obviously this is best achieved when the Earth and the target planet approach the closest points on their orbits. Such opportunities are called launch windows.

This may suit relatively nearby planets and those orbiting in the same plane as Earth. Consider, however, the relative distances of all the planets, as measured in astronomical units (AU), one of which represents the mean distance of the Earth from the Sun (about 93 million miles, 150 million km). The average distance of each planet from the Sun as we move outwards is: Mercury 0.39 AU; Venus 0.7 AU; Earth 1.0 AU; Mars 1.5 AU; Jupiter 5.2 AU; Saturn 9.5 AU; Uranus 19.2 AU; Neptune 30.1 AU and Pluto 39.5 AU.

So, to go beyond our immediate neighbours obviously requires a considerably greater effort. So far, only three craft have attempted it. One of these, America's Mariner 10, went to Mercury, the innermost planet, and two other identical craft, Pioneers 10 and 11, were sent to Jupiter and will become the first craft ever to leave the solar system. It will not be until the year 2015, however, that Pioneer 10, launched in 1972, will cross the orbit of Pluto, the outermost planet. Beyond there, it will journey on forever into the emptiness of space at a

CONTINUED ON PAGE 22

The cancelled Mars landing, as it was planned for 1980. Top: the twin spacecraft approach Mars, having swung past Venus on the way. Below, right: the projected landing on 14th August, 1983. The first craft is down and the three-man crew are on the surface, their rover vehicle's TV camera filming the descent of the second lander for the benefit of those on Earth and crews in the orbiting mother ships. The entire trip was to have taken 640 days and would have been the first manned trip to a planet.



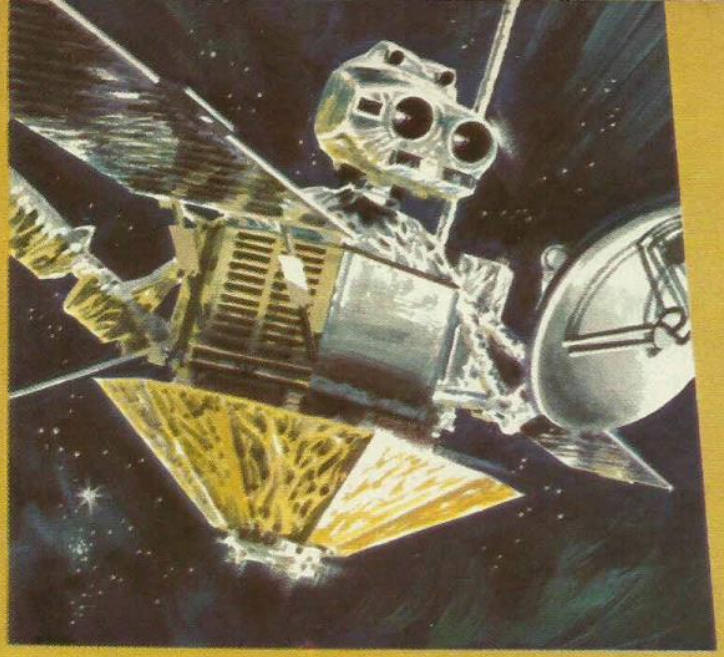
JUPITER UNVEILED

Moon and Mars had been explored. What should be their next target in space? The Americans chose Jupiter. On 2nd March, 1972, they launched Pioneer 10 (above) on a flight path to the red planet. Boosted on its way by an Atlas-Centaur rocket, Pioneer 10 was skimming past the Moon after eleven hours and by December of the following year it was in orbit around Jupiter sending back to Earth streams of information about the planet.

Pioneer 11 joined it a year later, and together the two ships filled in a lot of the gaps in Man's knowledge of Jupiter. This planet is a gigantic sphere of liquid hydrogen, they showed. It has no detectable solid surface, except perhaps a small molten or rocky core. In fact, its atmosphere is 82 per cent hydrogen, 17 per cent helium and 1 per cent other elements.

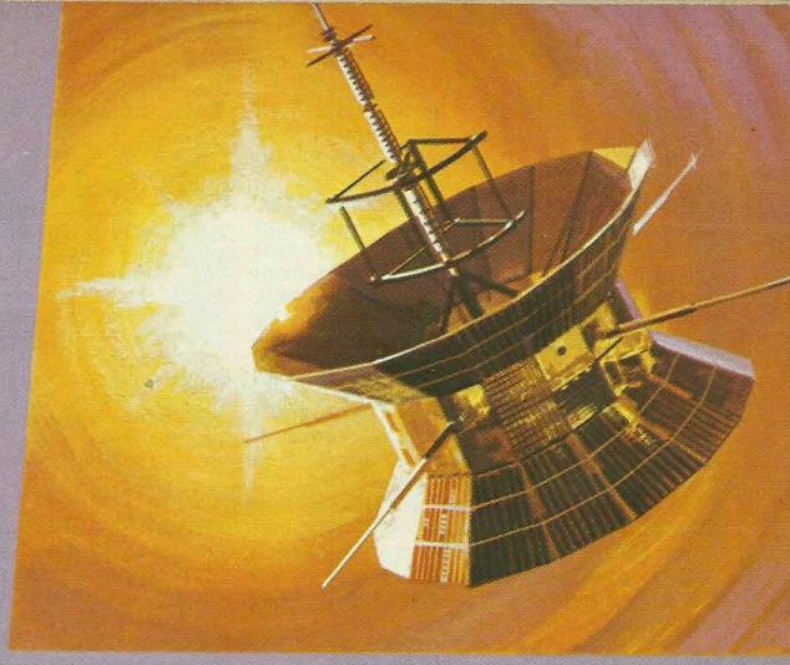
It does not seem likely that there is any life there, but it could possibly exist in the turbulent cloud tops, although it would have to be able to endure severe temperature extremes in the rising and falling atmosphere.

Both the Pioneers will eventually follow a route that will carry them out of the solar system and into the distant universe. Their flight path will take them through the rings of Saturn (above, right) when they should be able to provide an answer to the question about the rings' constitution. Are



FOCUS ON MERCURY

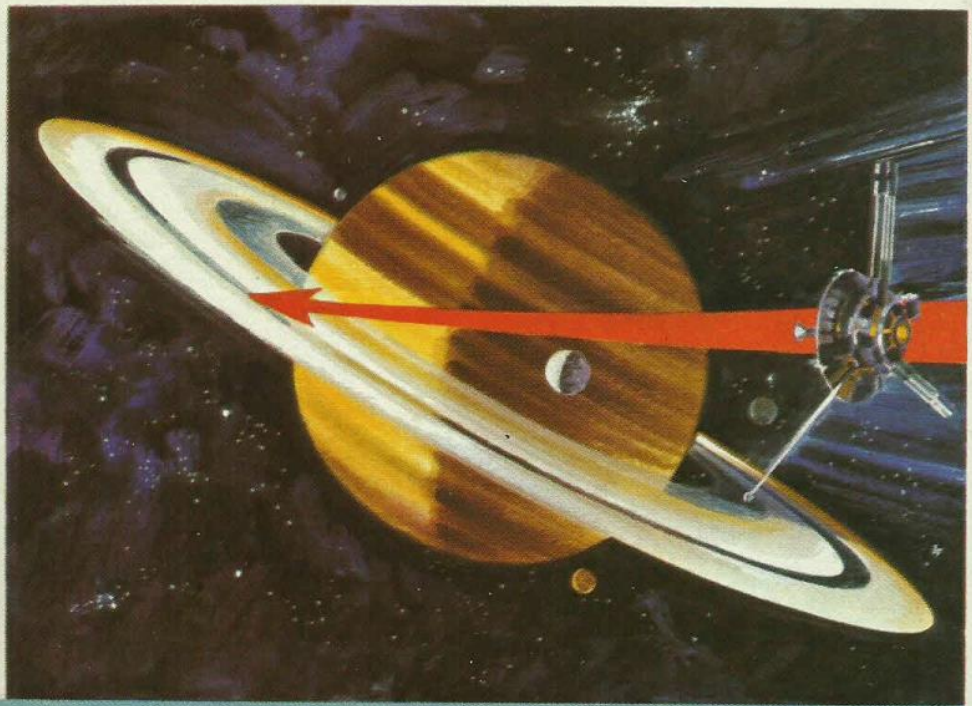
More than a thousand pictures of Mercury have been taken by a small space craft, Mariner 10. Launched in November, 1973, Mariner swung around Venus, recording data about the planet as it did so, and then set off for Mercury. During its third swing around this distant world it took a very close look at the crater-pitted surface. It came to within 198 miles (318 kilometres) of Mercury at its closed point and sent finely detailed pictures of it back to Earth. Mariner's instruments measured Mercury's magnetic field and added to our scientific knowledge of the planet.



STUDYING THE SUN

Designed to investigate the Sun at close range was Helios A, a German space probe launched by the U.S.A. in December, 1974. On 15th March, 1975, Helios got as close to the Sun as it could — within 28 million miles or 45 kilometres — and began making measurements of the solar wind, cosmic rays and interplanetary dust.

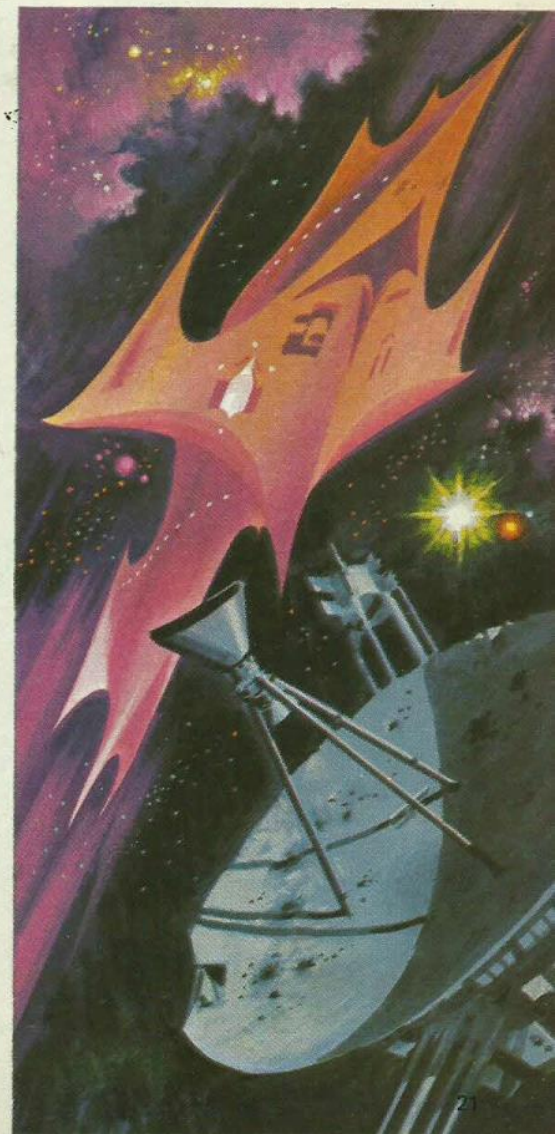
The object was to put Helios in a solar orbit so that it could continue to send data to a space operations centre near Munich, in Germany, where its findings were being monitored. It represented a big breakthrough in solar exploration.



they ice cylinders packed together to form a solid band (right, upper), or are they ice-covered rocks of different sizes, more widely dispersed? (right, lower).

Not until 1979, when Saturn is expected to be reached, will this problem be solved. Meanwhile, an even greater mystery is the eventual destination of the Pioneers. Will they land on a planet in some other solar system, or will they encounter a strange craft from another world, like the one on the far right imagined by our artist?

Perhaps some future generation of Earthmen will learn the answer to this.



speed of 25,000 m.p.h. It should pass near its first alien star, called Aldebaran in the Taurus constellation, in about two million years time.

Mariner 10 faced a special problem. Mercury orbits in a plane angled at 7° to that of the Earth. A very large expensive rocket would have been needed to achieve both the change in plane and the considerable change in velocity. Working on a theory by an American scientist, US space officials calculated that, if the craft were sent on a conventional flight to Venus at a time when Mercury was passing through a nearby part of its orbit, and if it passed by Venus at exactly the right distance and angle, then the gravity of Venus itself would drag the craft round in a curve and accelerate it cff to Mercury. It worked perfectly, the first application of a revolutionary technique called "gravity-assist", a technique which has now become our gateway to the outer planets.

This technique was used again by Pioneer 11 which, on December 3, 1974, passed close enough to Jupiter — its target planet — to be swung round on a course for Saturn. Its sister craft, Pioneer 10, launched a year ahead, has continued out in a more direct line and has crossed the orbit of Saturn on February 10 this year.

The future is even more exciting. Another pair of purpose-built Saturn ships is being sent off in 1977, again by way of Jupiter. Designed in the style of the sophisticated Mariner craft, rather than the fairly simple Pioneers, they will intercept and scan most of Jupiter's twelve moons, plus the nine moons of Saturn including mighty Titan, larger even than the planet Mercury, and the only satellite known to have an atmosphere. It will be 1981 when they reach Saturn, just 15 years after Luna 9 transmitted the first momentous pictures of the surface of our own Moon.

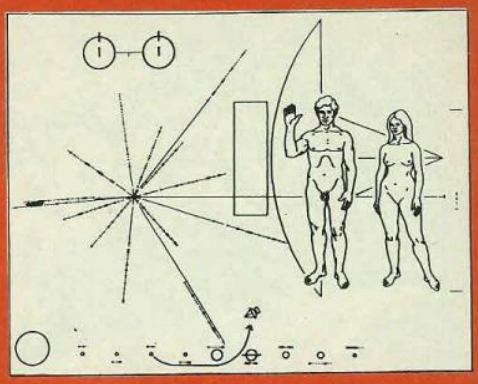
The 1977 missions are designed to cover part of the loss sustained when the Grand Tour was cancelled. The Grand Tour was to have been the ultimate in the exploitation of the "gravity-assist" technique. It was also to have spread the reach of Man to the farthest corners of the solar system. It was planned to make use of a unique line-up in the late 1970s of all the outer planets. Two pairs of ships would have been launched for Jupiter — now the jumping off point for the outer planets — one going on to Saturn and then way out to far Pluto; the other heading directly for Uranus and then Neptune. The pattern would have been complete. But the cost was too high and now the true nature of our more remote neighbours must remain a mystery until some unknown future date.

The next major step is still to be decided. For the forseeable future, space exploration is likely to involve consolidation of the gains already made, studying more deeply the planets so far inspected.

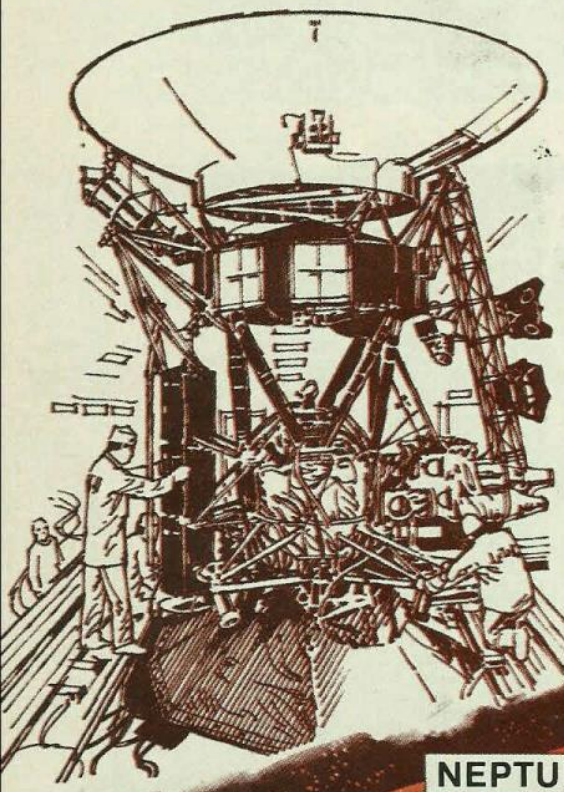
Already well under way is an ambitious exercise to extend studies of Venus with a pair of radically new spacecraft. Both consist of identical drum-shaped bodies, but while one has fuel and controls to place it in orbit, the other carries four cone-shaped entry probes on top.

These will all be released during the approach so that they can enter the atmosphere separately and provide relative measurements of the nightmarish blanket of boiling and crushing gases that enclose the planet. The studies will complement those made by Russia's Venera 9 and 10, from which landing capsules provided the first picture of the surface.

Orbiters and atmospheric probes for Jupiter and Saturn are now being seriously discussed by the US space agency, NASA, and a number of other more exotic robots are being devised. Before the next 15 years have passed it is quite possible that we will see automatic craft roaming the surface or returning soil samples from Mars and Venus, even Mercury. And one day, perhaps even within our lifetime, Man himself will step on to another planet.



This small plaque, measuring 6 in. by 9 in. (152 mm. × 228 m.) will be attached to Pioneer 10. It conveys information which intelligent life on another planet could interpret, in the remote possibility of such life being encountered beyond the solar system. Behind the people is the outline of the spacecraft, to provide a scale. The radiating lines represent 14 pulsars (pulsating stars) from which the sun can be located. On these lines are binary symbols representing the frequency of the pulsars' pulses at the launching time in relation to that of the hydrogen atom (shown at the top). This would give a clue to the distance travelled. A binary figure beside the woman indicates her height.



Some missions have used gravity assistance, using the giant pull of the planets to affect a space probe's flight path. The most ambitious, now cancelled, was the 1977-79 "grand tour" shown below. One flight was to use Jupiter and Saturn to hurl a probe out to Pluto. The other was to use Jupiter alone to fly past Uranus and Neptune. The necessary line-up of planets to make this possible will not occur again until 2155 AD. Left: NASA is preparing two giant Mariner probes, to survey Jupiter and Saturn, for launching in 1977. If the first is successful, the second may be re-directed on to Uranus. This is the third outmost planet of the solar system. Sir William Herschel discovered it in the year 1781.